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ELEMENTARY AGRICULTURE

By

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With A Foreword
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DEDICATED
TO
MY FATHER

FOREWORD

In a country where Agriculture is the principal Industry and where not less than three-fourths of the people are dependent on it, the importance of the dissemination of systematic and scientific informations on the subject, can never be over-estimated.

There is no gainsaying the fact that Indian Agriculture is still in an archaic state. With the immense potentialities of the soil assisted by bounties of Nature, there is no reason why people of India should not derive more crop and this can only be done by a more systematic and scientific agricultural system. This certainly requires education of the masses in the methods of modern and scientific Agriculture.

I have not gone critically through Dr. Mitra's "Elementary Agriculture" but from reading bits here and there, I have found it to be a very useful work for students of Agriculture as well as for those farmers who are keen on introducing scientific methods in their vocation.

If the principles and the methods set forth by Dr. Mitra are carried into practice, I am sure Indian Agriculture will attain the much needed fillip it deserves and the economic problem of the people will be solved to a large extent.

SHILLONG,
The 7th May, 1940.

SYED M. SAADULLA.

PREFACE.

At present our Indian cultivator has come to a status where the time-honoured agricultural practices, followed by his forefathers require a change to keep pace with the demand of modern civilization. Labouring under blind experience and ignorance and depending on *kismat*, he does not know how to improve his agricultural status in any way better. He is not willing to send his son to school to get even rudimentary education, although he wishes with all his heart that his son may read and write legibly and make a correct account of profit and loss in his humble profession. But, unfortunately, there are difficulties that stand in his way to educate his son. No matter what facilities there are for his son to go to the neighbouring school, he is always doubtful about the results, and moreover, he is afraid that his useful boy, after getting a little education, may follow his classmate, the *bhadralok's* son and give up the plough.

On the other hand, the *bhadralok's* son with all the pride and dignity that his class maintains, tries his luck in the crowded town, after he is through with his high school education, i.e., Matriculation. After vain searches for a job that can give him a chance to live an independent life, especially in consideration of high living in the town, he soon gets fed up and blames his own fate. The cry "back to the land" is right at his door.

Under the circumstances, the well-wishers of our country, especially those who are trying to solve the question of unemployment, may look to agriculture as a solution of this ever-besetting problem and demand its proper training in our public schools. The apathy of the common cultivator to send his son to school is mainly due to the fact that the lessons are not given in accordance with the life, the boys lead at home and that there is very little opportunity for them to learn something useful to utilize best in their own profession. As 80% of the people are cultivators, the introduction of the subject of agricultural training in the school curriculum is the only course to follow, as it will induce both the cultivator's sons as well as the *bhadralok's* to take up agricultural course in the school and follow it as a vocation.

It is to achieve this aim in our public schools that this book has been written in a simple way, giving an idea of the general principles of agriculture and the methods that are prevalent in our country especially in Assam and Bengal with suggestions for their improvement. In the preparation of this book attempt has been made to deal with the subject matter in a way that may be interesting both

to the teacher and the taught. The general questions and laboratory exercises that follow each chapter have been arranged in a manner that may make the students think for themselves and get themselves acquainted with both the theory and the practice under the guidance of a good teacher. Moreover, the book contains a number of illustrations of special interest which will make the students grasp the subject well.

In offering a course of agriculture the teacher is a great factor. He must have both theoretical and practical training in general agriculture and should know the means and methods that are followed by the cultivators of the province. He must have an aptitude for mixing with the local cultivators and be on good terms with them. With the permission of the school authorities, he shall have to prepare a suitable area for cultivation with the help of students, and allot a small plot, say $10' \times 10'$, to each one of them for practical work. The work should be planned out systematically ahead so that there may be no duplication.

An introduction of this subject in the school will give a chance to the cultivators' son to get himself trained in a subject which is his hereditary vocation. The practicums will be especially interesting to him, as he will find that, a living subject, with which he is surrounded in his own home is being taught. On the other hand, the *bhadralok's* sons will get a chance to understand the dignity of labour and the value of an open country life and will take it up as a more honourable profession than the job of a poor clerk, yoked to his table in a government or mercantile office. Moreover, in order to facilitate the introduction of agricultural study in our schools, an attempt has been made (appendix 2a and 2b) to offer two courses of study, viz., (1) for the students of Middle Vernacular and Middle English Schools and (2) for the High English Schools or training of Teachers for the Middle Vernacular and Middle English Schools with a sincere hope that it will help the school authorities and the teachers to organise suitable courses for their respective classes in addition to the regular 3 R-Training according to the University curriculum.

I acknowledge with thanks the help rendered by Messrs. N. K. Das, L.Ag. (Hons.), Assistant Marketing Officer, Assam and J. L. Sen, B.Ag. Botanical Assistant, Deep Water Paddy Research Farm, Habiganj, Assam, for going through the manuscripts. I am also deeply indebted to the latter for the pains, he has taken in going through the proof and his sincere efforts in arranging the publication of the book.

SHILLONG,
The 4th March, 1940.

S. K. MITRA

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CHAPTER I

THE SOIL

A. Formation of Soils

Perhaps you know that the shape of the earth which we live in is like an orange. The outer crust of this vast globular structure consists of loose granular materials which are generally known as soils. They are primarily derived from rocks that form the great ranges of high mountains and low hills that we see here and there. The disintegration of rocks, which is going on for ages through the action of various natural forces, causes the soil to be deposited in lower levels and thus it acts as a medium for the growth of plants—the foremost living beings on earth.

How the soil is formed from the rocks is not very difficult to understand. If you take two pieces of sandstone and rub them together, you will find small particles of sand formed between them. In nature's everlasting process of grinding, these sand particles are formed through various agencies and they become mixed with decayed organic matter to form the soil in our cultivated fields. The agents that are constantly at work in soil-formation are as follows :—

1. Moving water and ice.
2. Changes in atmospheric condition.
3. Action of living beings.

1. *Moving water and ice*—The work done by the moving water and ice in the formation of soil can easily be imagined when we think of the sources of the great rivers and the glaciers (rivers of ice) in the great Himalayan mountains, that border the northern part of India as a gigantic wall from Kashmere to Assam. The constant flowing of the rivers, which swell during the rains, carries down part of rocks with them and so the river beds in higher altitudes are found covered with boulders and gravel in winter season (Fig. 1). By a continual grinding action these boulders and gravel become smaller and smaller as they come down to the

plains where they are found in the form of sand. Thus the soils, we see on both sides of a river, are alluvial soils which consist of sand and silt containing organic matter, and are the most fertile tracts for the growth of various cultivated crops.

The great Himalayan ranges that bound the northern part of India are covered at the top with prepetual snow. Any of you, who have ever visited Darjeeling or Simla, may have seen the snow-capped mountains even in summer. In the process of thawing of

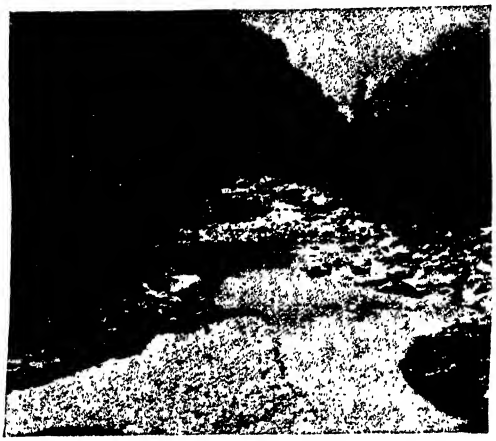

FIG. 1. A hill stream showing boulders and gravel in winter [Cachar].
By the courtesy of A. B. Ry.

snow large ice sheets come down rapidly grinding the soil and plants underneath. In this way many glaciers are formed and big boulders are found to be strewn here and there with their edges worn off and rounded. Thus, the constant rolling and the grinding of the rocks ultimately cause the formation of soil which is taken down and deposited on the lower levels, the river banks in particular, in which our cultivated plants are grown.

2. *Changes in atmospheric condition*—The changes in atmospheric condition are brought about by two important factors, viz., (a) Heat and cold, and (b) Wind.

(a) *Heat and cold*—Perhaps you know the common physical phenomenon that heat expands and cold contracts a material. You might have noticed that the wooden fixtures in a corrugated iron house, after a bright sunny day, make a cracking noise in the evening or at dead of night, especially after a cold spell. Likewise, as the rocks are brittle, the changes in temperature at day and night cause unequal expansion of the rock-forming materials, resulting in

the cracking or breaking up of rocks and ultimately small chips are thrown out from their surface. If a piece of rock is heated and then suddenly dipped in cold water, it almost crumbles to pieces. All the rocky mountains in our tropical regions are subject to this physical action of atmospheric changes in temperature. In the cold regions as that of the Himalayas, the expansion of the freezing water in the crevices of rocks in the ice-capped mountains causes them to split and crumble to pieces and thus helps in the formation of soils. Moreover, high temperature in general helps in the dissolution of rock-materials.

Another physical phenomenon that plays an important part in the splitting and cracking of rocks resulting in the formation of soils is earth-quake. Perhaps you know that the interior of the earth is extremely hot consisting of vapour, gas and molten materials. The volcanic eruptions, caused by this geological force, frequently throw out loose fragmentary materials and stream of molten rocks or lava which form a soil of a peculiar type.

FIG. 2. Drift of sand on the wall of a pucca house partly covering the growing cactus [Puri].

(b) *Wind*—Another atmospheric agency, the wind, plays an important part in wearing out rocks. It is very frequent in the higher altitudes of mountains. It not only wears away the surface of rocks, but also transports the soil from one place to another. The latter action is very prominent in the formation of numerous sand heaps in the islands in the delta land of Bengal. Moreover, the same phenomenon is observed in the formation of sand-dunes found in the sandy coast of the sea. Some of you might have witnessed such an action of wind in the sea coasts of Orissa (Fig. 2).

Such sand-dunes are also met with in the deserts of Rajputna, which looks like a sea of sand.

3. *Action of living beings*—Among the living beings, plants and animals are the two agencies in the formation of soils. The plants with roots, firmly established in the crevices of rocks, pry them out with great pressure (Fig. 3.). The ruinous action of banian trees is very common in old *pucca* houses and walls in our country. Besides, during the process of their growth, the roots produce an organic acid which dissolves the rock-materials. Even

FIG. 3. Prying action of roots on a rock
[Vashista, Gauhati]

the lower plants, such as lichens and mosses, which are found to cover the open rock surfaces, have a similar effect and they gradually gather debris in which the higher plants get a foot-hold in course of time. Furthermore, the soil possesses a large number of micro-organisms, such as the bacteria and the fungi, that help in soil formation by decomposition of organic materials. The action of micro-organisms in soil is really very important in crop production. On the other hand, micro-organisms play no less an important part in the formation of soils. Darwin has estimated that earth-worms can produce a layer of 2 inches of soil in a year. Besides this, wild and domesticated animals and men help the disintegration of rocks by their constant treading.

It may also be pointed out that the chemical actions of some gases (Oxygen and Carbon-dioxide) and acid (Carbonic and Nitric) in atmospheric air and moisture on the decayed and decaying animal and plant materials change the texture and the structure of the soil.

B. Character of soils

Whenever you think of the character of soils, you shall have to deal with their general texture and structure. The former denotes the coarseness and fineness of soil particles; while the latter refers to the manner in which soil particles are connected with each other in relation to their size. They come under consideration in preparation and irrigation of soils in our cultivated fields. Because where the rainfall is low and consequently there is not much leaching of soils, the coarser soils such as the sand, and the sandy loam, are much more productive than similar soils in rainy humid climate. If the soil is too loose and open, there is great difficulty in irrigating owing to excess of seepage and loss of humus in the absence of sufficient calcium in the soil. Such is the condition mostly found in many places in North Western India including Bihar, United Provinces and the Punjab. On the other hand, the clay and clay loam soils of Assam and Bengal are so compact that it is difficult to till them and to maintain their proper state of cultivation for other crops than the paddy.

The physical constituents of the soil, that we see in our cultivated fields and gardens are sand, silt and clay; intermixed with decayed organic matter, called *humus*. This humus is a complex, organic substance of plant and animal origin which consists of organic materials, resistant to further decomposition and of substances, undergoing decomposition. The black substance that is found in particles in the soil is the remnant of the decayed organic matter, the humus, which is, essentially needed for crop production. This humus which gives a black colour to the soil, is ordinarily deposited within six inches of the top soil, below which the soil is either light yellow or grey. The deeper the humus-bed, the better the soil for crop production. In Assam and Bengal where the rainfall is so high, this humus is washed away gradually from higher to lower levels by heavy showers and consequently the soil, especially in higher altitudes, is depleted of its fertility for crop production. This is commonly found in the Khasi Hills where potato or maize will not grow well unless well-rotted farmyard manure is applied to the soil.

The ordinary method of cultivation practised in the hills is known as the *Jhum*. The jungle is cut down and burnt on

individual beds, arranged vertically downward on the hill slopes in January to March which invites more washing away of the soil. Seeds of hill rice, millet and job's tears are dibbled. Cotton, potatoes, *til,* chilles and pumpkins are also grown in the *Jhums.*

A *Jhum,* as a rule, is cultivated for 2 or 3 seasons and then left fallow for 7 or 8 years and the cultivator has to seek a new land for *Jhuming.* This is a ruinous system of cultivation which has caused the hills to be sparsely populated.

The best method of successful cultivation and permanent land-holding is to adopt the terraced system (both wet and dry) of cultivation, as is generally found among the Mao-Maram and Tankul Nagas. In this system the slopes are cut into successive terraces, which are irrigated from hill streams, where water is carefully distributed through little channels.

Mechanical classification of soil

Soils are generally designated as (1) Sand, (2) Clay and (3) Loam. In our cultivated fields they always occur in mixed forms. They may roughly be classified mechanically according to the percentage of sand and clay they contain in each case as follows :—

(i) Sandy soil	..	80-100	per cent	sand and	0—20%	clay.
(ii) Sandy loam	..	60—80	„	„ „	20—40 „	„
(iii) Loam	..	40—60	„	„ „	40—60 „	„
(iv) Clay loam	..	20—40	„	„ „	60—80 „	„
(v) Clay	..	0—20	„	„ „	80-100 „	„

1. *Sandy soil*—Typical sandy soils are found in deserts, sea coasts and river bottoms where very few plants are found to grow. Sand particles are larger than clay particles and they have more area in pore-space than the latter and consequently they do not retain moisture which quickly precolates downward. But sand can be used to improve a stiff clay soil that forms clods, thus allowing more moisture and air which are needed for the growth of cultivated crops in the field.

2. *Clay soil*—Clay soil particles are very small. They are often very difficult to deal with ; because they become sticky when wet and hard when dry. They hold water and humus.

Humus, generally found on the surface layer of a soil, may not be sufficient to make it loose especially in clay. The addition of lime or manure in such a case makes it more porous. This improves the aeration of the soil as well as drainage which are the

two main requirements of a good cultivated soil. The vast low-lying areas in Assam and Bengal which are especially clayey in nature, are particularly adapted to paddy and jute, the two staple crops of our country. The new alluvial tracts are also suited to the growth of rabi crops, such as mustard, pulses etc., which do not grow so well in the older alluvial tracts especially where clay predominates.

3. *Loam soil*—The loam soil is a mixture of sand, clay and humus. It may be divided into sandy loam, and clay loam according to the quantity of sand mixed in it, as has already been explained. This type of soil is most suitable for crop production, as they contain humus. A large portion of the alluvial soil of both Assam and Bengal comes under this type.

There are some other typical soils which may be briefly stated as follows :—

1. *Humus soil*—Although there is humus more or less in most of the soils, there is a typical soil which can easily be recognised by its dark colour. Such soils are met with here and there both in the hills and the plains of Assam and Bengal. Such a soil responds very satisfactorily to proper cultivation and drainage. The peat soils containing over 10% of vegetable matter also belong to this class. They are rare in Assam and Bengal except in some swampy depressions in the plains, bordering the Himalayas.

2. *Limestone or Calcareous soil*—The limestone soil contains from 20-30 per cent lime. The soils of the southern part of the Khasi Hills are of limestone origin. This is the source of the so-called "Sylhet Lime," found in the market. Hundreds of lime kilns are found on both banks of the Surma river. The limestone of Katni in Central Provinces is also well-known. The marl soil containing from 5-20 per cent of lime also comes under this type. Such a soil is met with in the sedentary deposits in the foot-hills, bordering the Sylhet district, where oranges thrive well under natural conditions.

3. *Alkali soil*—The alkali soil is so-called, as it contains a large amount of alkali salts of sodium, calcium and magnesium. They are found to cover the greater part of Bombay Presidency, parts of Central Provinces and Berar, Madras and Hyderabad. The true *Usar* or *Reh* soils are rather difficult to handle. Only proper irrigation and drainage can reclaim alkali soils, which are not usually found in Assam and Bengal.

4. *Acid soil*—The acid soil of Assam is well-known. The acidity is due to some undecomposed organic compounds of doubtful origin which is termed humic acid. Such a soil does not allow the growth of many of our rabi crops, such as wheat, barley, oats and tobacco. But it favours the growth of acid-loving plants such as potato, tea, *arhar*, rhea, etc. The acid soil in Assam is commonly recognised in old alluviums by the natural growth of *phutuki* plants (Melastoma) and thatch grass in waste areas. (Fig. 51). In order to improve such a soil good drainage and application of lime or potash are necessary.

Testing the acidity and alkalinity—Whether a sample of soil is acidic, alkaline or neutral can easily be tested as follows :—

Take a lump of soil and work up into a ball with water. Cut the same in two-halves. Put a piece of blue litmus paper on the cut-side of the ball and then join the two-halves together. Keep it in the same position for half an hour, after which time cut open the litmus paper. If the soil is acid the litmus paper will be turned red. If a red litmus paper be placed in the above manner and found to be turned blue after the interval of half an hour, then the soil is alkaline. In the absence of any change in colour, the soil may be taken to be neutral.

In fact, there is no ideal soil that can naturally be found for cultivation. It may lack in one or other of the materials necessary for an ideal growth of plants. The soil should, therefore, be analysed in a chemical laboratory and the required ingredients should be added accordingly to make it fit for the purpose of cultivation of desired crops. It may well be noted that when we speak of "light" and "heavy" soils, we generally refer to sand and clay. They do not refer to the weight of soils; because we find that the light soils are actually heavier in weight than those which are called heavy soils. Lightness or heaviness really implies the resistance that is offered by the soil for the manipulation of implements. In fact, the lighter the soil, the easier it is to plough and cultivate.

Generally clay soils, when baked hard in dry season, form clods which are very difficult to plough. The cracking of the soil is an indication of its clayey nature (Fig. 4). Clay soil should be ploughed when it is still moist after the harvest. On the other hand, a loam or a sandy soil can be ploughed at any time of the year as desired.

The one-crop system in Assam and in many parts of Bengal, especially in the old alluvial tracts, is mainly due to the clayey nature of the soils which clod so hard after the harvesting of

FIG. 4. Cracking of soils in a low-lying area.

paddy is over in winter that it is really very difficult for the cultivator to plough until the soil is softened by sufficient precipitation next summer. Any attempt to solve this problem is worth undertaking which will open the way for two crops a year.

QUESTIONS :

1. What is soil ? How does it originate ?
2. State briefly the action of the soil-forming agents.
3. Can you change the texture of a soil ? If so, how ?
4. How can you prevent the clodding in your paddy land ?
5. What is the effect of application of lime in the soil ?
6. How can you grow crops in the grassy plains near the foot-hills of the Himalayas ?
7. Why can't you grow jute and pulses in the clayey old alluvial tracts ? Is there any remedy for this ?
8. Are the silted river banks and islands in the delta land of Bengal and elsewhere good for crop production ? If so, why ?

LABORATORY EXERCISES :

1. Take a lump of earth from the garden and put in a wide-mouthed bottle. Fill the bottle with water and then shake. Let it stand for a time.

   Note the different layers of sand, silt and clay and describe the nature of each.

2. Feel the nature of different kinds of soils, such as clay, loam and sand, by pressing them between the fingers. What do they signify?
3. Observe the rush of water after a heavy rain in May and dig the earth (uncultivated) with a hoe. How far down does the water enter in the soil? Observe the same in a cultivated field.
4. Note the various samples of soils exhibited by the teacher.
5. Collect samples of different types of soils—sand, silt and clay in small bottles and label them.
6. Work up sufficient soil into a ball with water and then cut the same into two halves. Put a piece of blue litmus paper on the cut side. Then join the two halves together and leave it aside for a time.
   Is the soil acid or alkali? How do you know it?

CHAPTER II

THE WATER

Water is essential for the maintenance of life of all the living beings on earth. As we cannot live without water, so do plants. We sip water through the mouth and plants perform a similar function with the help of roots which go down deep into the soil. Now, let us see how water moves in the soil.

A. The water cycle

You generally see the water, stored up in ponds, rivers and seas. This water does not feed the roots of plants and is not so important to them as the atmospheric water.

Water evaporates from the land as well as the surface of vast sheet of water as vapour. This water vapour comes up in the air and as soon as it comes in contact with a cold draft, it forms fog or cloud which is then carried by the wind to fall down on the earth as dew or rain. This water is stored in the soil to supply water to both plants and animals. The water again evaporates from the surface of the earth and also transpires from the leaves to the open air. It thus moves in a cycle.

B. Water in the soil

The water in the soil is found to exist in three states, viz, (1) gravitational water, (2) capillary water and (3) hygroscopic water.

1. *Gravitational water*—You might have noticed that after a rainfall the major portion of water runs off to the neighbouring pond or the river and a part of it also sinks in the soil by gravitational force. This water percolates down and reaches a final level, commonly known as the ground water level, which is formed over a hard layer or soft bed of clay situated at different depths in different places. It may be 100 feet deep in one place and only 20 feet in another. This should always be considered in boring a tube well. During heavy rains in the plains of Assam and Bengal this water

level rises up to the surface of the ground in many places. Such a condition is not frequently met with in Northern and Central parts of India.

The running water, which is thus taken down by the force of gravity, is known as gravitational water. It is this free water that feeds our rivers and ponds. This water carries away a good deal of soil and plant food with it from one place to another. This is noticed most in streams and rivers during the rains. You might have seen a river bank being washed out in the rainy season by strong current, carrying away a good deal of soil and exposing the roots of trees (Fig. 5). This water cannot be used by the

FIG. 5. Soil erosion on the river bank due to strong current.

plants. Generally, if the soil is not ploughed, a major portion of water does not enter the soil, but runs off to the neighbouring streams, canals or rivers. Ploughing and cultivation allow water to soak in the soil and conserve it there until needed by the roots of plants.

2. *Capillary water*—Many of you have noticed that if a piece of cloth is put in water partly, the water rises up through the cotton fibres and wets the rest of it. The same phenomenon is noticed in a lamp wick and likewise in the soil. The soil soaks the water like a sponge after a precipitation which is again given off by evaporation. The force which causes liquids to pass upwards through a porous substance is known as capillarity. Generally,

this capillary water rises up to the top slowly through the pore spaces in the soil and is evaporated to the open air. Water attains the greatest height in clay and the least in sand, but up to a certain height its movement is quicker in sand than in clay. A major portion of the water in the soil escapes in this way. Cultural practices, such as ploughing, mulching and addition of humus to the soil, check the loss of capillary water by evaporation. This capillary water is most utilised by plants.

3. *Hygroscopic water*—If you imagine each soil particle to be covered by very thin films of moisture like a sugar-coated *luddoo*, then you will easily understand the hygroscopic moisture. These thin water films will adhere to the soil particles even in a sample of sun-dried soil. But, if the soil is heated in an evaporating dish, it will pass off water as vapour, which will be absorbed again as soon as it is cooled down. This is the hygroscopic water. Plants cannot possibly use it under normal conditions.

Water requirement of plants

Just like animals, plants require food and water without which they cannot grow. A major portion of this water in our country, especially Assam and Bengal, is supplied by the monsoon rains. Owing to the failure or lack in proper distribution of the monsoon rains drought occurs in some part or other of a province resulting in a general crop failure bringing in famine. Our cultivators who grow rice and jute know fully well the importance of sufficient water supply in season for producing these two staple crops.

The plant food in soil remains in solution. It is one of the activities of roots to draw this nutrient solution up through the stem to the leaves, where it is utilised in part in manufacturing starch and sugars. Water is also evaporated from the surface of the leaves. It has been estimated that for every pound of dry matter produced in grain crops, there is need of from 200 to 500 lbs. of water. This water is used in building up plant tissues, about 90% of which are water.

There are two kinds of typical soils in relation to water supply, both of which are important in our crop production. They may be named as (1) Water-logged soil and (2) dry soil.

1. *Water-logged soil*—A soil, situated on the slope of a hill or on a higher level is always well-drained. Such a soil is very suitable for fruits and other crops, such as wheat, barley, mustard, tea, sugarcane, cotton etc. The soil in the lower levels, where there

is no outlet for water, always remains water-logged. Apart from paddy and jute, most of our cultivated crops do not grow in such a soil. Water-logged soil is generally found to be acid, especially during the dry season, and should be improved by proper cultivation before any crop is tried.

2. *Dry soil*—Typical dry soils are found in the Punjab, United Provinces, Sind and other places where the rainfall is very low. Such soils are not met with in Assam and Bengal. But, however, owing to the failure of monsoon, a soil may be too dry in a particular period of the year to produce any crop. It is for this reason that every year many a crop fails in one part of the country or the other. A loose soil or a sandy soil is liable to be dried up in this way. In a place where such a condition prevails owing to the lack of proper amount of precipitation, or in other words where the rainfall does not exceed 30-40 inches, either irrigation or a system of dry farming may be adopted. The latter necessitates the conservation of soil moisture by frequent cultivation, mulching and fallowing the land. The dry regions of N. W. Bengal and Behar come under this group of soils.

Evaporation from soil may well be checked by a mulch. Any material, put on the surface of the soil forms a mulch. It may be artificial; such as the use of straw or dried leaves to cover the soil. A natural soil mulch may well be formed by proper tillage. To be effective, a mulch, when applied must be dry and loose. Soil water cannot quickly evaporate through it and consequently plants do not suffer from lack of moisture.

The general tendency of the soils, specially clay loam to clay soils in our cultivated fields, is to become compact by the action of rain water. This is detrimental to the development of roots of most of our crop plants. The evil is intensified by lack of areation owing to the formation of a crust by clay and cracking of the crust, causing the moisture to evaporate quickly. It is, therefore, necessary to stir up the soil so as to prevent the formation of clods and bring it to a friable condition in which state roots thrive well. Application of farm yard manure and green manures helps in bringing out that tilth and friability.

QUESTIONS:

1. What causes the plants to suffer where there is too much or too little water in the soil?
2. Name the three ways by which water moves in the soil. Which is most useful to plants? Why?

3. What is a mulch? What is the use of it?
4. What do you understand by ground water-level? When does it come up and go down? Why?
5. What remedy do you suggest in the following?
   (a) Where there is too much water in the soil.
   (b) Where there is too little rainfall.
6. Why is it that wheat grows in well drained lands and does not grow well in low-lying water-logged fields while paddy behaves differently?
7. What is the best way to conserve the soil moisture?
8. Where does the soil go when washed away by the strong current of a river?
9. Generally we find that grasses grow in the plains and trees in the hills. Why is it so?

LABORATORY EXERCISES :

1. Take a lamp wick and dip a part of it in water. Note the results.
   Take two glass tubes, one one-fourth and the other one-eighth of an inch in diameter. Dip them in a glass of coloured water and notice the rise of capillary water. Note down your observations.
2. Take five long Ditmar lamp chimneys. Tie the bottom with a piece of thin markin cloth and fill them with dry sand, silt, clay, loam and sandy loam about three-fourths. Put them in a rack and place a basin under each chimney. Now pour water slowly from above until the soil is moistened thoroughly. Notice the water that passes out for a time.
3. Arrange the same chimneys as in No. 2 and instead of pouring water in them place the chimneys on a flat dish, having water in it and notice for a time the rise of water, moistening the soil. Note the results.
4. Take three flower pots. Fill one with sand and the other two with clay and keep one with clay covered with a mulch of cut straw. Expose them to hot sun for two days. Weigh before and after drying. Note down your observations.

CHAPTER III.

IRRIGATION AND DRAINAGE

A. Irrigation

All of you may not know that in places where the rainfall is not quite sufficient, irrigation is absolutely necessary for the growth of crop plants. Such a condition is met with in all the north-western regions of India from Bihar to the Panjab and also in the Central India. Even in Assam and Bengal where only the monsoon rains prevail, it is necessary to irrigate the *boro* paddy as well as the *rabi* crops, such as cabbage, potato, onion etc.

(a) *Water scarcity*—Perhaps many of you have noticed the yellowing of *aus* (summer paddy) and jute seedlings in March and April for lack of moisture. If the drought continues, this results in a failure of crops. Unless there is a sure source of water supply, the guarantee of a full crop can hardly be assured. Our cultivators mostly depend on the natural precipitation which is not always distributed well and hardly know any remedy to solve the problem of drought. In paddy fields the cultivators recourse to small dams, commonly known as *ails*, around the individual plots to make the rain water stand in the field, but this does not help them when the drought continues. This is a reason why a field, although owned by one individual, is separated by *ails* into small plots.

Sometimes cultivators use the basket or the *don* to irrigate their *aus* crop, if there be scanty rain in April and May. But this is not possible in every place and especially on a large scale. Had there been any irrigation facility in every locality to get water as desired, there would have been no crop failure and two crops could be produced easily. This would have been a great advantage in many parts of Assam and Bengal where only one-crop system prevails.

In all the way from Bihar to the Panjab one witnesses the lift of water from *kachha* wells in the fields and orchards by a pair of bullocks. The cultivators of Assam and Bengal ought to follow the

same method, provided they want to grow two crops a year. The failure of pulses in the old alluviums is mainly due to the lack of sufficient moisture. Digging a *kachha* well at a suitable corner of the field will materially help the cultivators not only in producing *rabi* crops but in getting water when they need it most for preparation of the soil for early paddy, the *aus*. This is no doubt a poor method, because on many occasions wells do not supply as much water and as quickly as is needed for the crop in the field. But, however, it will help the cultivators to grow an earlier and a better crop. It would certainly be better if water could be pumped up from rivers or from large artesian wells especially made for the purpose in each locality. The recent introduction of irrigation pumps for *Boro* cultivation in Assam is a real success.

(b) *Water supply*—The modern system of irrigation is illustrated by the work of the Punjab irrigation canals, Sukkur Barrage scheme in Sind and the great irrigation dam at the Merikanev lake in Mysore State. In irrigating a section, water may be led through pipes, flumes and open ditches. There are also side ditches jutting out of the main here and there from which water is directed by means of a division box or similar other device to irrigate the fields of cultivators. Such arrangements have made it possible to grow crops in many places in the Punjab and Sind which were quite barren before the installation of the watering system.

Contrivances for irrigation—Irrigation is generally required in winter months in Assam and Bengal, but still there are some places where it is necessary for growing *sail* paddy. There are many contrivances for irrigation which mostly depend on the situation of the land, climatic conditions and the crops grown.

1. *The dong*—The *dong* system of irrigation is prevalent in Assam as already stated. Considering the situation of the low-lying areas, interspersed with so many hill streams from the high land areas, the simple method of bunding the streams to raise the water and diverting them to the lower field is really very useful. In many places even opening out of the silted mouths of the *khals* of the streams helps in irrigating vast areas for paddy cultivation. The disadvantage of this system lies in the fact that the bunds are sometimes washed away by the on-rush of the flood water and the mouths of the *khals* become silted up in a few years. *Pucca* bunds are highly desired.

2. *The Well*—Wells are commonly found everywhere but their depths vary a good deal, the variations being dependent mostly on the ground water level. The raising of water by a bucket is

common in Bengal and Assam and is seldom used for field irrigation except in vegetable gardens. In United Provinces and Western India the usual method is to raise water by means of a large bullock or buffalo-hide bag drawn by a pair of bullocks. This contrivance of drawing water is known as the *mote* in the Deccan.

3. *The Persian Wheel*—The Persian Wheel is mostly used in the Punjab. This is a large vertical wheel, fixed over a well with a looped chain of earthen or metallic pots attached to it. When the lower part of the chain goes down, the pots come up filled with water. As the wheel moves, the pots empty themselves into a trough. This is also driven by bullocks.

4. *Water Pumps*—The rotary pumps, run by engine power is the best means of irrigating a field. Its initial expenses are realy very high, amounting to Rs. 1500|- for a pump and an engine for ordinary purpose. Such a pump can irrigate an area of 500 acres, provided the level of the land permits water to pass through the channels without any difficulty. In such a case, the source of water may be a river or a *khal*, as is the case in irrigating the *Boro* fields in the Surma Valley.

Methods of irrigation—There are various ways in which a field can be irrigated of which the following are discussed below :—

1. *Flood system*—Flood system is the easiest way to irrigate a field. In this, water is to be turned on to the field until the whole field is under water. This system is good for paddy and jute cultivation and has successfully been adopted in the paddy areas in California and Carolinas in U.S.A. If the field is not level, it is not easy to work this method. In order to avoid this difficulty the check system is mostly adopted.

2. *Check system*—In the check system the field is divided into individual plots with dams or *ails* all round as is very often noticed in our paddy fields. Each individual plot is then irrigated with advantage. This is the best method for all crops. Both the flood and the check systems of irrigation will save a crop of potatoes or sugarcane from a bad drought and also from the attacks of white and red ants, rats, cut worms etc.

3. *Furrow system*—This is the best system when crops are grown in rows. Furrow system suits well for sugarcane, vegetables and fruit gardens. For this purpose deep furrows are to be made between the rows by a plough and water is to be turned on them from the higher level. The furrow system of irrigation is adopted by the potato and onion growers of Assam and Bengal.

4. *Overhead irrigation*—The use of a watering-can may be taken as the simplest type of overhead irrigation. But, irrigation water may also be supplied from above by fixing water pipes all round the field several feet above the ground. This may pay on special money crops and such arrangements are useful in vegetable gardening. In California, U.S.A., some of the rich orange growers have installed this system to do away with the labour. The opening of a stopcock is quite enough to make a shower on the trees in an orchard, whenever required. Such a luxurious system is not possible for our Indian farmers.

It must be pointed out here that over-irrigation is always harmful to crops. Only well-drained soil is suitable for such irrigation, otherwise water-logging condition may arise. Moreover, in order to conserve the moisture the land should be cultivated after the irrigation is over, so as to loosen the top soil, which will act as a mulch to check unnecessary evaporation.

B. Drainage

(a) *Water-logging*—You may often wonder why in the tea gardens of Assam, the planters spend so much money to cut 3 feet deep narrow ditches at every 30 feet. There is sufficient reason for it. Just as animals require a thorough working of the system by the removal of waste products, the soil needs drainage. This means that the water that enters the soil from above passes out as a waste material carrying with it many toxic substances that are produced in the soil which, if not removed, will not allow plants to grow freely but on the contrary will kill them ultimately. Both the acid soils of Assam and the alkali beds in Bombay, Madras and Central Provinces need drainage by which these toxic substances are removed. Moreover, drainage is necessary to facilitate the aeration of the soil so that plant roots can have access to oxygen which helps proper bacterial activities in the soil. Experience shows that sticky clay soils do not produce any other crop than paddy unless they are well-drained.

It is sometimes found that when a field is ploughed, water accummulates in the furrow. This is an indication that the land needs drainage. Soils, producing weeds like burdock, arum and polygonum also indicate that there is too much moisture in them. Such a soil requires drainage. Even when rain water stands for a long time in a field, it injures the roots of all plants except paddy and jute and so drainage is necessary.

Types of drains—There are two types of drains (i) Open drains and (ii) Underground drains.

I. *Open drains*—Open drains are nothing but mere narrow ditches cut for the purpose. Though they are easy to make, they take up a good deal of space in the field. Besides, they divide the field into smaller parts, which interfere with easy ploughing, and other cultural operations in the field.

In the low lying *beels* or marshy lands of Assam and Bengal reclamation work by proper drainage is urgently needed to destroy the breeding places of malarial mosquitoes as well as to make the land fit for crop production. There are vast tracts of high land in the plains of Assam especially the grassy plains on both sides of the Assam Bengal Railway, which may be reclaimed by open drainage, which means prosperity and permanent settlement in agriculture (Fig. 6).

Fig. 6. A low land water-logged throughout the year requiring drainage.

II. *Underground drains*—Owing to some defects of the open drains, as mentiond above, underground drains are more useful for field operations, but the cost of installation is often prohibitive. Where organized capital controls the farming as a business on an intensive system, such as the fruit or the tea industries of Assam and Bengal, such an investment may be profitable in the long run. In the case of tea, as cultural operations are done by human labour, the disadvantages to open drains are not so apparent. However, underground drainage can be adopted with advantage in fruit gardens.

Generally underground drains are laid beneath the ground about 3 feet deep. Tile is the best material of the construction of under ground drains. In the United States of America the farmers invest a good deal of money to instal such underground drainage in their vineyards, orange or lemon orchards. Once laid up, it is good for

years to come. But the great disadvantage of underground system in an orchard lies in the fact that sometimes roots, penetraing the tubes cause a break down in the system by clogging drains, which is not easy to locate.

It may also be mentioned here that underground drainage is desirable only in cases where capital farming is adopted and the profit is quite consistent with the cost of its installation.

QUESTIONS :

1. What should a cultivator do when there is too much rain and the water-level is near the surface ?
2. What should the cultivator do when there is too little moisture in the soil during the drought ?
3. What determines the need of irrigation or drainage in a land ?
4. State briefly how the soil in our cultivated lands can be irrigated or drained properly.
5. Why do plants wither in drought ? How to save them ?
6. Why do maize seedlings turn yellow in a low-lying land in the rains ? How to save them ?
7. Do orange trees in your locality yellow in winter ? How can you check it ?

LABORATORY EXERCISES :

1. Take two flower pots. Close the bottom hole in one with paraffin and fill both of them with garden soil. Sow some peas in each and then pour water in paraffined one until the soil particles are wet and moisten the other. Note from day to day the germination of seeds in both.
2. Take two similar pots. Fill them with clay soil. Plant a few maize seedlings in one and paddy in the other. Pour sufficient water. Notice the difference of growth of the plants.
3. Take trips to a field during the rains and note the paddy, jute, sugarcane and maize growing in both high and low lands.
4. Visit a tea garden, if possible, and note the methods used for drainage.

CHAPTER IV.

WEATHER AND CLIMATE

We generally speak of the weather and the climatic conditions of the locality where we live, but we seldom think of their effects on crop plants in our surroundings. The reading of this chapter will give you an opportunity to understand how rainfall and temperature, which you read in our daily newspaper, are being recorded.

In growing crops weather and climate are of great importance. These two determine the supply of moisture, sunlight, temperature, barometric pressure, wind and cloud. A change of weather means a change in one or other of these elemental forces of nature. Therefore the weather in any place may be described as the continuation of all these atmospheric phenomena existing at one time. At present our newspapers publish a weather record of the day in different parts of Assam and Bengal. The data of rainfall and temperature are collected daily from different parts of the country. You might have noticed a rain-gauge in your own town, situated either in the Thana or the Post and Telegraph office compound. From a reading of these data one can easily know the general weather conditions of the province and guess the weather for a day or two ahead in a locality.

A. The Weather

The daily changes in the pressure of atmosphere, as is shown by barometric readings, are indications of the changes in wind and temperature and commonly called the weather. The prevailing winds determine the amount of moisture and temperature of the atmosphere. Therefore the barometric readings are very important in weather records.

In order to study the atmospheric conditions the following instruments are necessary, as shown in Fig. 7.

1. Thermometers.
   (a) Wet and dry bulb thermometers.
   (b) Maximum and minimum thermometers.

2. Rain-gauge.
3. Barometer.

Generally air contains moisture more or less which is easily felt when dry hot wind blows. The percentage of saturation of air with moisture is called "relative humidity" or "humidity" in popular phraseology. This humidity of air can be determined by a wet and dry bulb thermometer (Fig. 7. a) There is also a costly apparatus which records the humidity directly in small weekly charts.

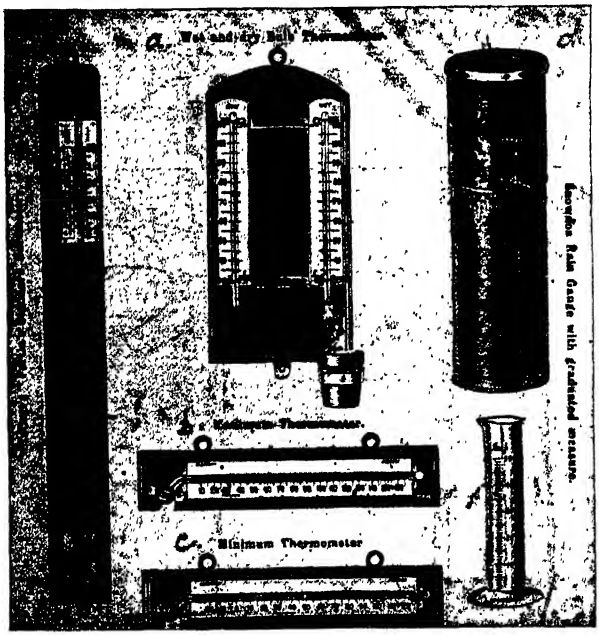

Fig. 7. Appliances for weather reading required in a school house through the courtesy of Messrs. Baird and Tatlock & Co.

The plains of Assam and Bengal are extremely humid, the Upper Assam, especially the Sibsagar district, having the highest humidity. The hills, on the other hand, are comparatively less humid and consequently are drier than the plains. The humidity of the western part of Bengal, Bihar, United Provinces and the Punjab is lower and consequently they are drier.

The maximum and minimum thermometers (Fig. 7 b & c) will w the diurnal maximum and minimum rise and fall in temperature which is important for a normal growth of crops both in summer and winter seasons. For example, you might have noticed the withering of the tender shoots of many trees after a sudden cold

spell in January and February. Likewise, the excessive summer heat during a drought causes the wilting of many of our garden vegetables.

At present there is a rain-gauge in each sub-divisional head-quarters. It is a simple apparatus, consisting of a copper or glass funnel, the top of which has a certain area and the neck fits into a glass bottle. The funnel and the bottle are enclosed in a metallic cylinder (Fig. 7 d). The measurement of the rainfall is made by pouring out the contents of the bottle into a graduated glass cylinder especially made for the purpose. It is expressed in inches of rainfall. *Fig. 8* shows the wooden weather shelter and rain-gauge used at the Agricultural Experiment Station, Jorhat. The weather shelter contains the barometer and the thermometers.

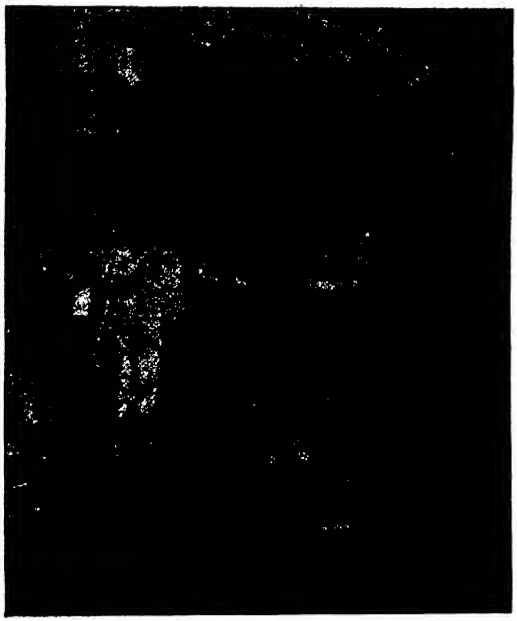

Fig. 8. Weather shelter and rain-gauge (Agric. Expt. Station, Jorhat).

The barometer is an instrument which, like the thermometer, shows by its rise and fall fair and foul weather. The reading is made in the height of the mercury column. Variations in the weight of an arc often accompained by change in the condition of wind and temperature of the atmosphere. A general rise in the mercury column foretells the fine weather that follows which is likely to last longer than when the rise is a sudden one; similarly,

a gradual fall usually indicates continuous wet or unsettled weather. When the barometric reading suddenly falls down, it means that a storm is coming soon. When the mercury column begins to rise after being low for some time, the wind often increases considerably in strength. Furthermore, in winter months, a rise in the barometer indicates the approach of cold weather whereas a corresponding fall is accompanied by a milder weather.

A barometer should be placed in a room subject to as little variation of temperature as possible; it must hang vertically, the height from the ground being such that the reader may read it comfortably.

The Climate

The climate may be defined as the average phenomena of heat and moisture which prevail for a considerable period in any given place, or in other words the average state of atmosphere in regard to heat and moisture and other meteorological conditions that exert an influence on animal or vegetable life. The chief four factors that determine the climate of any place are :

(1) The distance from the equator.

(2) The height above the sea level.

(3) The distance from the sea.

(4) The prevailing winds.

Moreover, the lesser influences that affect the climate of a place are mainly the direction of the mountain chains, the slope of the land, the nature of the soil, the natural forest and the degree of cultivation in a country.

The Alipore (Calcutta) Meteorological Department is the centre of weather records for Bengal, Bihar, Orissa, and Assam. There are many delicate instruments to record the forces of nature. The forecasts of weather are daily telegraphed to Alipore from different parts of the provinces. Weather charts are issued every day from this station for publication in newspapers.

There is a great difference in climate from one place to the other which modifies the production of crops. The difference is due to the varying altitude or height, latitude or distance north and south of the equator, proximity to ocean, sea, big lake, river or desert and variable winds or mountains. This is the reason why the natural vegetation of a landscape differs from that of another, especially in the higher altitudes and the plains. Furthermore, it is due to this

difference in climatic conditions that we find deciduous fruit trees, such as apples, pears, peaches etc. being grown in the higher altitudes of the Khasi Hills and Darjeeling, and evergreen fruit trees, such as oranges, mangoes, litchis etc. thriving best in the lower altitudes and the plains of Assam and Bengal. It is the same climatic conditions that make the pines to grow over 2000 feet above the sea level in Assam and Bengal below which they do not thrive at all.

Another important factor in the plant and animal lives is heat which comes from a source, many thousand miles away from the surface of the earth. In fact, the sun is the source of all heat. This heat warms up all that we see. Like light, heat is also reflected. The atmospheric moisture and gases (carbon dioxide) absorb a part of the heat and wherever moisture and gas predominate, we feel comparatively warmer. The top of the mountains, being cone-shaped, does not contain much moisture and gas in air and so does not absorb enough heat which is reflected down to the plains. That is why the top of the mountains like Shillong and Darjeeling is cooler than the foot hills or the plains.

Perhaps you know that the planet earth, staying in a permanent position of its own, moves round the sun in its own orbit which is a much bigger body than the earth itself and is the source of light and heat to our planetary system. The diurnal changes in temperature from morning till evening are due to the fact that the sun glances to the earth at the nearest distance at noon than in the morning or evening.

The change of season is another phenomenon which can be well understood when you can realize the movement of the earth in its own orbit. You might have read in your geography that in moving round the sun, the earth changes its orbit because of the inclination of its own axis and the path deviates more from its right-angular position to the sun or in other words the sun approaches the horizon as the cold weather begins. That is, in summer the earth moves nearer to a right-angular position and the sun is directly over head, while in winter the position tends to move in the opposite direction.

The physiographical features, such as the sea, mountains and plains are of great importance in the distribution of temperature, humidity and rainfall. The wind, blowing six months in one direction and six months in the opposite direction, is known as the monsoon. This monsoon affects the climate of Assam and Bengal most prominently. The North East Monsoon is a season of great

dry winds and lightly clouded sky with light seasonal rainfall. On the other hand, the South West Monsoon is a season of winds of high humidity and of frequent and heavy showers. About 95% of the rainfall occurs during this S. W. monsoon.

QUESTIONS :

1. What do you mean by the weather and the climate of a place ?
2. How is the climate of a locality affected by altitude, latitude, proximity to a large body of water and winds ?
3. What are the monsoon winds and how do they affect the climate of Assam and Bengal ?
4. What is indicated by the fall of the barometric reading ?
5. What causes the annual floods in the Brahmaputra and Assam Valley and the delta land of Bengal ?
6. Why has Cherrapunji the heaviest rainfall ?
7. What is the use of the maximum and the minimum thermometers and the rain-gauge ?

LABORATORY EXERCISES :

1. Study in the laboratory how to read a barometer, thermometer and a rain-gauge.
2. Calculate the humidity from a reading of the wet and dry bulb thermometer (consult the chart in the appendix IX).
3. Determine the inches of rainfall from a reading of the rain-gauge after a shower.
4. If there be an inch of rainfall in your reading, how much moisture is supplied to your school compound ? (1″ rainfall=101.1 tons per acre approximately).

CHAPTER V.

THE PLANT

You always see the plants in and around your homes and fields. They are of great economic importance. We owe our life to them. They clothe and feed us. You will find a great interest in studying them.

The plant is a living organism with organs of different forms and shapes in its body proper that serve the purpose of growth, maintenance and reproduction, as is generally the case with other living beings on earth. Unlike the latter, it anchors itself to soil, displaying its leaves towards the open horizon. You ought to know the main parts of the plant and the functions they perform during their whole life time.

Parts of the Plant

The parts of the plant are formed of the following organs :—

1. Root.
2. Stem.
3. Leaf.
4. Flower.
5. Fruit.
6. Seed.

1. *The root*—The roots of a plant go down in the soil, hold it fast there and absorb from it the nutrient solution, which is carried through the stem to leaves. The stem and the leaves are phototropic, i.e., go up towards the light, while the roots are geotropic, i.e., go down in the earth which is dark. The root system of trees such as mango, orange etc. consists of a tap root and lateral roots both of which go down deep in the soil. The roots of grasses and plams are fibrous, and are found to be scattered mostly in the top soil (Fig. 9).

The root has root hairs which grow periodically. These root hairs are the organs that absorb the soil solution. They are found in all higher plants. The main tissues are the water-conducting tissues *(xylem or sap wood), food-conducting tissues (phloem or bast)*

and the wood. The soil solution is absorbed by root hairs and passes through the xylem to leaves, whereas the food materials manufactured in green leaves, are translocated through the phloem to other parts of the plant.

Air is needed for the growth of living roots as well as for other parts of plants. Consequently, roots require aeration, i.e., the supply of oxygen. Many of our cultivated plants will die when the land goes under water for a long time, while other plants, like

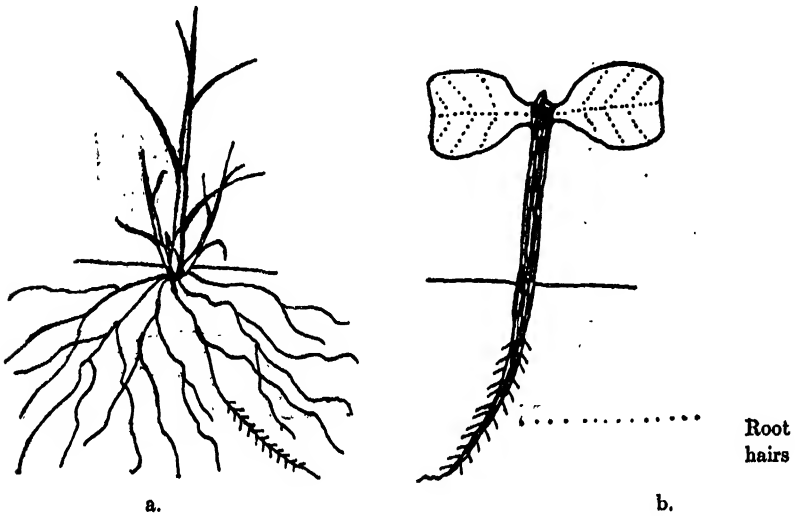

FIG. 9. Roots. *a.* Fibrous roots of a rice seddling. *b.* Tap root of a young tamarind seddling showing root hairs.

paddy and jute, will grow very well when the land is submerged, as they have a power of toleration to water-logging. When sugar-cane and orange trees are water-logged, they turn yellow, because the pores of soil are clogged by water and air cannot get in. This brings a condition in the soil that suffocates roots. Such a plant may recover, if the soil is drained out properly. But roots of paddy and jute will tolerate submersion, as they are able to secure oxygen through the internal air spaces of the plants.

Root growth—In order to allow a free growth of roots, the soil must be ploughed deep, harrowed and cultivated well, so as to make it friable and of right texture for the growth of roots of crop plants. During the dry season in winter, when the soil gets hard and cracks badly, big clods are formed which become almost impenetrable to roots. The failure of *rabi* crops, especially pulses in the old alluvial clayey soils, is mainly due to this bad clodding of the

2. *The stem*—The part of the plant above the root is the stem which forms the central line, the axis. It bears leaves, buds on the axil of leaves and also flowers and fruits. In most cases stems are upright aerial structures which expose leaves to the bright sunlight and thus make it possible for a greater display of leaf area. The water-conducting and the food-conducting tissues are in the fibro-vascular bundles of the stem. (Fig. 10). The former carry the water up to leaves, while the latter carry the elaborated materials down to the stem, roots, and other parts where they are required.

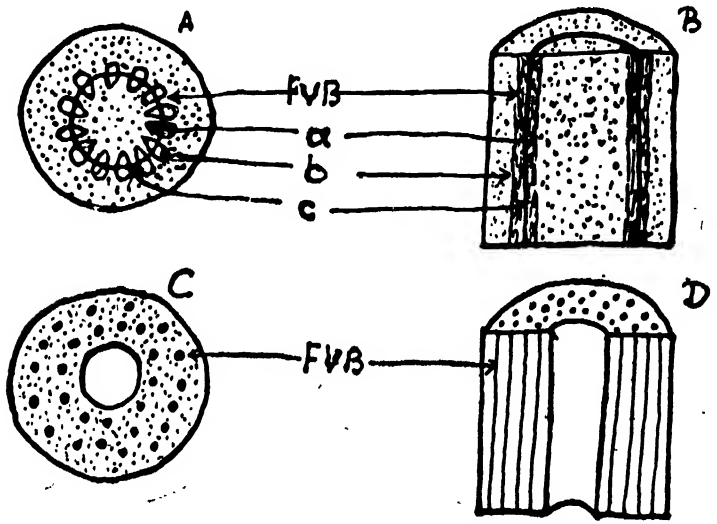

FIG. 10. Stem. A and B, cross and longi-sections of dicotyledonous stem of castor. C and D, monocotyledonous stem of rice, F. V. B.—Fibro-vascular bundles. *a*, water-conducting tissues (xylem) ; *b*. food conducting tissues (phloem) ; and *c*, (cambium).

In some plants the stem serves as a store of food. The potatoes are an example of such underground stems, while in sweat potato and radish the underground portion, where food is stored, is the root and is known as tuberous root.

There are two kinds of plants bearing two different kinds of stems—the monocotyledon (mono=one, and cotyledon=seedleaf) and the dicotyledon (di=two, and cotyledon=seedleaf). The former is represented by grasses and plams, while the latter by the mango, tamarind, castor etc. The dicots are the plants which have two cotyledons in the seed, whereas the monocots have only one cotyledon. When a dicot stem in cut across, the fibro-vascular bundles are found to be arranged in the form of a ring whereas

in monocots the fibro-vascular bundles are scattered. The stem consists of water-conducting, food-conducting, cambium and mechanical tissues. Jute, rhea and sunnhemp fibres are nothing but such fibro-vascular bundles of the bast. The dicots have heart wood and sap wood which are lacking in monocots.

The length and the diameter of the stem of plants depend largely on the conditions under which plants live, namely, the available water supply, amount of light, temperature and fertility of the soil. They really determine the success of a crop, especially in yield. This is evidently noticeable in places where crops are grown under unfavourable conditions. The failure of *ahu* or *aus* (summer and autumn paddy), sugarcane and jute is not very uncommon in our country.

3. *The leaf*—The leaf is the most conspicuous part of a plant and is the most important organ, owing to the fact that it manufactures food such as protein, fat and carbohydrate, which are used by the plant itself as well as other living animals and man for their maintenance and growth.

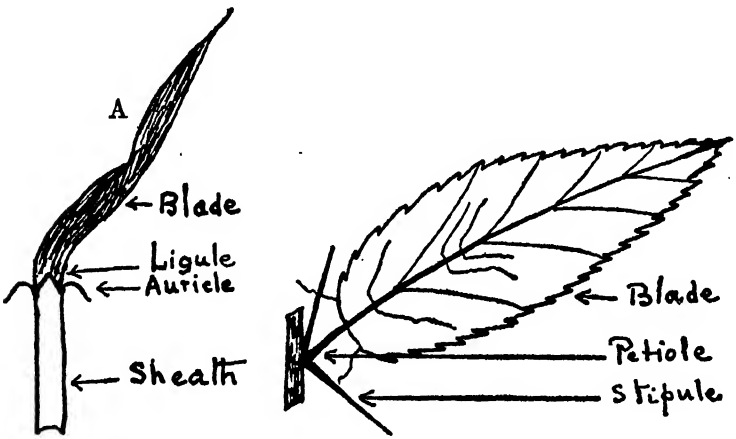

FIG. 11. Leaf. A, leaf of a monocot [rice] and B, leaf of a dicot [jute].

Structure of a leaf—The leaf mainly consists of a thin blade, interspersed with numerous veins. The part that subtends the leaf from the stem is the petiole which in many cases bears two small appendages called stipules. So, the main parts of a leaf are the blade, petiole and leaf-base or stipules. But all plants do not have stipules at their leaf-base. In monocots, leaves consist of a sheath, blade and a ligule (Fig. 11).

Tissues of a leaf—The leaf is made up of soft green tissues which are essential for food production. The green colouring matter in the leaf is the chlorophyll. This may easily be shown by cutting a cross-section of a leaf which consists of five tissues—the Epidermis, the mesophyll and the three tissues of the veins, viz., the water-conducting (xylem), the food-conducting (phloem), and the mechanical (spindle or cylindrical cells with heavy walls) tissues (Fig. 12).

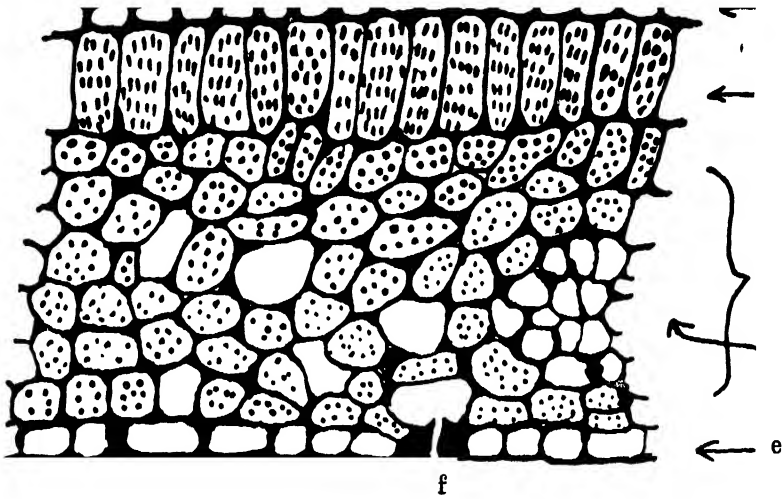

FIG. 12. Cross-section of a castor leaf.

a.—Upper epidermis. b.—Palisade layer. c.—Spongy layer. d.—F. V. B. Messophyll tissues
e.—Lower epidermis. f.—Guard cell.

When the cross-section of a leaf is looked under a microscope, the tissues are seen to be composed of small chambers like those of a honey comb. These small chambers are the cells. Each cell has a jelly-like living matter called *protoplasm*. In this protoplasmic mass there is an oval body called the nucleus which is the most important organ in a cell so much so that a cell is often defined as a nucleated mass of protoplasm. Each cell is a unit and a higher plant is built of millions of these cells. It is really surprising to think that the space covered by a pin hole in a leaf contains about 10,000 cells.

Like animals, plants have a breathing process. Scattered among the colourless epidermis of leaves, there are very small pairs of crescent-shaped green cells, called guard cells. Each pair of these

guard cells has an opening or pore, the *stoma*, which is opened or closed by the expansion and the contraction of the pair of guard cells. In most plants stomata occur on the lower surface of leaves (Fig. 12).

Manufacture of food—It is the green plants which have the power to manufacture the food. They alone can synthesize simple substances, that they obtain from the soil and air into complex bodies, known as carbohydrates, i. e., the starch and sugars which are fundamental food for both plants and animals.

The process of manufacturing starch and sugar (glucose) in the leaf by chorophyll with the help of sunlight is called *photo-synthesis*. The starch, we obtain from rice, wheat and barley and the sugar in sugarcane and date palm, come in this process. The other food materials, protein and fat, are also produced by the plant but the process of their manufacture is very complicated.

In manufacturing food, plants use carbon-dioxide from air, which is taken in by the stomata of leaves, and soil solution which is absorbed by root hairs. It is only the chlorophyll of the green tissues that forms with the help of sunlight starch or glucose which is the first product of photosynthesis. All the green parts manufacture food when they come in contact with sunlight, but most of the starch and sugars are manufactured in leaves.

Transpiration of leaves—You know how water evaporates from a piece of wet cloth, when exposed to air. Likewise, the water passes out as vapour, through the stomata and this process of giving off of water vapour is called *transpiration*. This phenomenon occurs when the plant is exposed to air. The rate of transpiration depends on some environmental factors, namely, temperature, humidity, movement of air, supply of moisture and the kind of plant.

The amount of water given off in transpiration is surprisingly large. During its life time a paddy plant gives off in transpiration from 200 to 300 times its own weight of water. So, you see that for the best growth of plants, there must be enough water supply in the soil for transpiration and assimilation of nutrients by plants.

Water supply to crop plants—Adequate supply of water is of utmost importance to crop plants. Some plants require more water than others. This is especially the case with paddy and jute. Occasional droughts bring forth disastrous results in these crops, especially in the higher levels. During hot sunny days, when air is dry and there is no rain, the rate of transpiration increases very rapidly to cause wilting of plants. This is very often noticed in

rabi crops and vegetables, such as mustard, pumpkin and amaranth families. Similar cases are also noticed occasionally in the early crops of *aus* and jute which suffer badly and sometimes turn yellow for want of proper moisture supply, especially in the sandy inundated areas of Assam and Bengal.

4. *The flower*—The development of roots, stem and leaves makes up the first period of life of a flowering plant. These are the vegetative parts of plants, which later on help in the process of reproduction and accummulation of food. This period of development may be termed the vegetative phase, whereas the development of flower, fruit and seed is the reproductive phase of a plant.

The flower is the organ for reproduction of seed. It contains bright coloured parts that are always attractive to the eye. Moreover, each type of flower develops more or less a sweet scent of its own which attracts bees that gather honey from flowers and thus accidentally perform the function of natural cross-fertilization that is needed in many plants.

The flowers in plants are arranged in different ways. In many plants they occur singly as in cotton and rose. In others they are arranged in groups as in the panicle of paddy and wheat, the catkin of willow and oak, the umbel of onion and corriander, the raceme of amaranth (*danta*) and the composite head of marigold and sun-flower.

Floral parts—Most of the flowers that are so showy in our garden are subtended by a stalk, the pedicel. The outerwhorl of the leaf-like appendages is the calyx, the sepals of which are mostly green. The next whorl of similar structure is the corolla, the petals of which are rather coloured brilliantly. Inside the corolla there is a group of stamens, each of which has an anther at the apex. This anther bears the pollen, the male element in plants. The centre of a flower is occupied by a pistil or pistils, which are mainly the ovulary, having one or more ovules which develop into a seed (Fig. 13). The pollen, when mature, falls on the stigma or is carried to it by some agents as wind or insect. This pollen fertilizes the ovule and the seed is produced.

5. *The fruit*—The fruit is the developed reproductive organ as a result of flowering and pollination. In the ordinary sense of the word, it is the edible and palatable juicy pulp ; surrounding the seed. In fact, the ripening of the enlarged one-celled pistil and ovary with a single seed or stone is the fruit as in mango, litchi peach and plum. They are single fruits and are known as drupes

or stone fruits. On the other hand, the fruits, developed from more than one pistil, ovary or ovules may be called the compound fruits, to which the majority of our common fruits belongs. In some cases the calyx tubes enlarge to form the fruit as in apples, pear and quince, which are called pome fruits. Among small fruits, such as blackberry and raspberry, the fruit itself is an aggregation of small simple berrylike fruits with edible pulp, all arranged in an elongated receptacle. They may be called aggregate fruits. The mulberry closely resembles the blackberry except that numerous

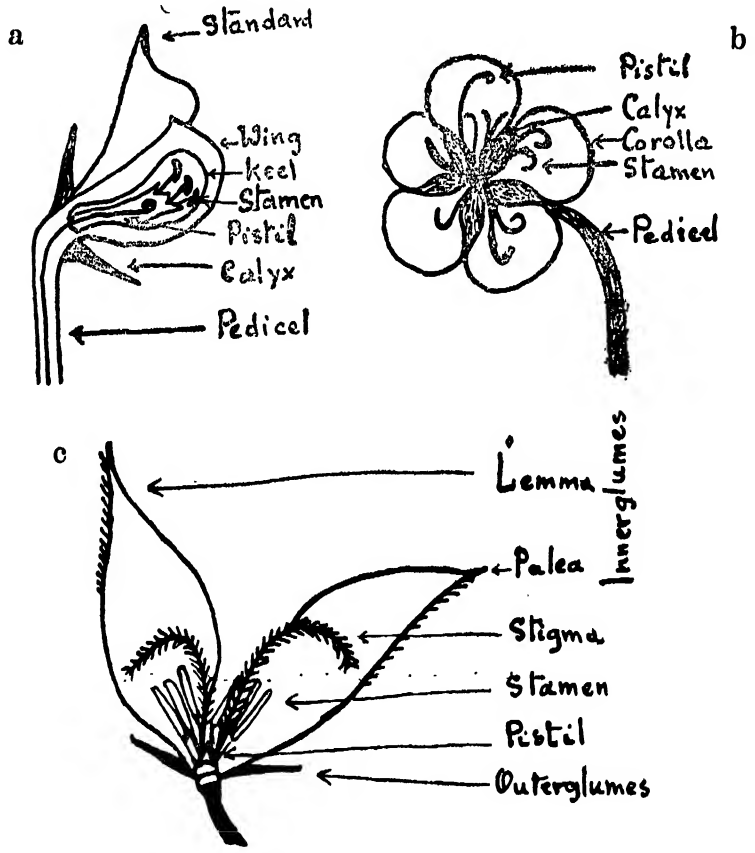

FIG. 13. *Flower.* (*a*) Showing the Floral parts of a pea, (*b*) Phtuki and (*c*) Rice flower.

pistils are united with their succulent calyx. Again, the jack-fruit and the pineapple are multiple fruits of this kind, formed by numerous ovaries, floral envelops, and bracts, combined into a succulent mass. Unlike mulberry, the common fig has the peduncle being hollow with numerous seeds inside, whereas the strawberry is the fig

with the inside out, having numerous ovules or seeds. Moreover, the orange and the lemon are berrylike in structure, having thick spongy rind, the ovary containing one or more seeds, surrounded by pulpy separable cells (vescicles). The custard apple (*ata*) is a fruit with fine pulp and protruding ovules with flat seeds.

6. *The seed*—Seeds and grains supply the most concentrated food derived from plants. They provide the larger part of food of all human beings. The grains supply the bulk of carbohydrates, protein and fat in our diet. The seeds of cotton, cocoanut and mustard supply the oils that are used as food. Linseed oil is largely used in paints. From rice, wheat, maize, barley and oats we get starch, glucose, alcohol, ether and many other related organic substances of every day use. The seeds of coffee and cocoa supply us stimulating drinks. The cloth, we wear, comes from the hairy covering of the cotton seed. So you see how useful seeds are in our every day life.

Seeds require different lengths of time for germination, some requiring more time than others. Those which take a shorter period for germination are called soft seeds and those, taking a longer period and having hard coats, are termed hard seeds. The value of good and pure seeds can only be known by germination test, which may be conducted easily by putting seeds between two

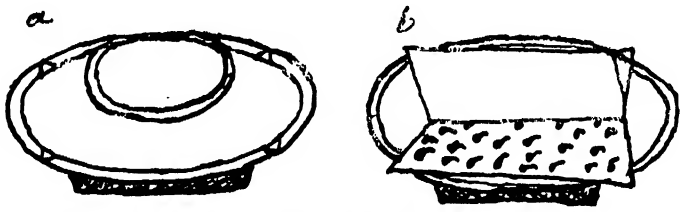

FIG. 14. Germination test of seeds in an earthen dish

pieces of blotting paper, preferably in an earthen plate, *sanki*, and covered by a similar one (Fig. 14). The seed should always be kept moist. One hundred seeds should be put in and in 2-3 days or more the percentage of germination should be counted. In the germination of seeds the essential factors are adequate supply of moisture, heat and air. The moisture makes the seed swell by absorption. By so doing, it exerts a pressure which opens the hilum, the opening, through which the germ comes out. Simultaneously, the food materials (starch, protein and fat) become soluble and supply the nutrition to the seedling.

Seeds do not germinate without air, i.e., a supply of oxygen. This is the reason why the seeds of all crops except water plants,

such as the paddy fail to germinate in water or water-logged soil. Moreover, without a certain amount of heat, starch does not become soluble and seeds fail to germinate. The amount of heat, required for germination varies greatly to different kinds of seeds. However, the optimum temparature for germination of seeds of our crop plants is about 80° F.

QUESTIONS :

1. In what ways do plants help us to maintain our life ?
2. What are the functions, performed by roots, stems and leaves ?
3. What are the materials and machineries, with which the plant manufactures food ?
4. Why does a crop plant not grow well under shade ?
5. What parts of the floral organ of the following plants develop into fruits :— Mango, stawberry, apple, jack-fruit, pineapple, roseapple and walnut.
6. What is the difference between a monocot and a dicot ? Show by a diagram.
7. How does the root absorb soil solution ?
8. What happens to a plant if the bark is taken off from the stem or trunk in the form of a ring ?
9. How does the plant transpire water ?
10. What is a seed ? How does it germinate ?
11. What are the best conditions for a seed bed ?

LABORATORY EXERCISES :

1. Take one earthen-ware plate (*Sanki*). Put a layer of sand in it. On it spread one hundred paddy seeds. Keep it covered with another earthen-ware plate. Sprinkle water every day and observe the germination of seeds and the growth of seedlings. Note the results in your note book.

Do the same with a few mustard or pumpkin seeds and note the results.

(*a*) What do the cotyledons signify in each case ?
(*b*) What do the roots signify in each case ?
(*c*) Do the soil particles remain attached ; when you take out a seedling ? What does it signify ?

2. Take a small box, fill it up with sand and sow two rows of tamarind seeds in it—one with hilum up and the other with hilum down and note the results :

(*a*) What does the hilum signify ?
(*b*) Why does tamarind take a longer time to germinate than the mustard seed ?
(*c*) What is the difference between the two positions of the hilum ?

Repeat the same with pumpkin or cucumber seeds.

3. Take three glass bottles and put some cotton or rag at the bottom. Moisten the first and keep the 2nd dry. Pour water in the 3rd. Put a dozen *matikalai* seeds in each bottle and leave them aside. Note the results :

(*a*) Does the seed need moisture ? Explain.

(*b*) Does the seed need air? Explain.
(*c*) How does water get into the seed?

4. Keep a dish, containing germinated seeds in a dark place and note the results.
   (*a*) Does the plant need light?
   (*b*) Why do seedlings turn white, when grown in a dark room?

5. Take two Erlenmyer flasks. Fill one with distilled water and the other with muddy ditch water. Fix a small paddy seedling in each by a cork and note the results:
   (*a*) Does the plant need food?
   (*b*) Which flask contains more food?

6. Put in a flower pot some *arhar* or *matikalai* seeds at different depths from 1"—12" and note the results:—
   (a) Do all the seeds germinate, if not, why?
   (b) What is the optimum depth for sowing the seeds?

7. Draw the diagram of a mustard, a mango and a rice flower, and name the parts.

8. Draw the diagram of cross and longitudinal sections of jute and paddy stem and leaf.

9. Draw a diagram, showing different stages of germination of a pumpkin seed.

CHAPTER VI.

PLANT FOODS

As we eat and drink nutrient food for the maintenance and growth of our body, so does the plant. The only difference lies in the fact that we derive our food from plants, while they in their turn, derive it from the soil and the atmosphere.

Nutrient Elements

There are a number of plant food materials which in their chemical forms are derived from the soil and air. Of these 14 elements are very important for the maintenance of plant life. They are :—carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorous, potassium, calcium, magnesium, sodium, manganese, chlorine, iron and silicon.

The plant takes the carbon from the carbon dioxide in air. Oxygen is taken both from air and water and hydrogen is likewise taken from water. Except leguminous plants, such as beans, peas, *matikalai* etc., nitrogen is derived from the soil. Certain bacteria take the nitragen of air and deposit in the roots of legumes in the from of nodules (Fig. 15). The rest of the materials are dirived from the soil in solution through the agency of root-hairs.

The soil contains all the elements of plant food. Of these; the most needed materials are nitrogen, phosphorous and potassium. These are known to be the three "limiting factors" in crop production, when other things are equal. Because, if any of these elements becomes exhausted in the soil, the plant will suffer a great deal. They may be discussed briefly as follows :—

1. *Potassium*—Potassium is one of the essential elements of plant food. When the soil becomes deficient in it, plants become shy in root growth and fruit or seed production. Root crops, such as potatoes, sweet potatoes, radishes etc. will not succeed unless there is a liberal supply of potash in the soil. Application of ash, manure and potash fertilizers is the best way to supply potash in the soil.

The best example of the beneficial effects of potash supply in the form of ash is found in the *Jhum* caltivation in the hill section of Assam and Bengal. The burning of the brush wood no doubt destroys a part of the phosphorous and the nitrogen of the soil, but increases the potassium content which allows the growth of potatoes, paddy and other crops for three years only. After this, the land becomes sterile owing to the lack of nitrogen and phosphorous and so it is given up.

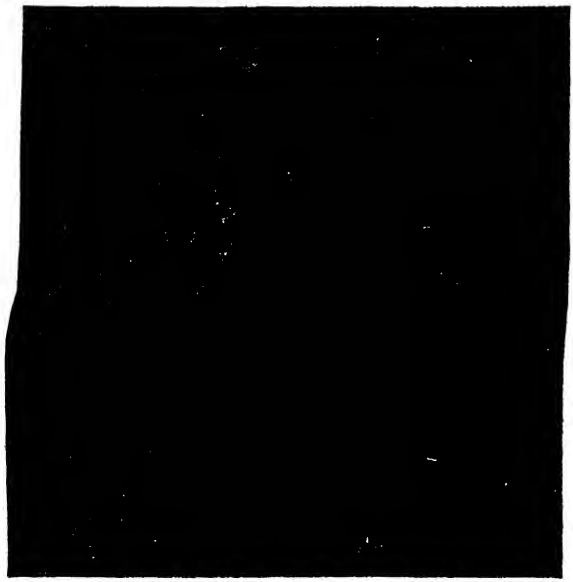

FIG. 15. Dhaincha roots, showing nodules of nitrifying bacteria.

2. *Phosphorous*—Plants require phosphorous both for growth and for the production of sound plump seeds. If the soil be deficient in this material, the plant will be arrested in growth and the crop will fail. Phosphorous can be supplied in the soil in the form of farmyard manure and phosphoric acid fertilizers. For this reason the rock phosphate or superphosphate may be applied in the soil with advantage. The recent introduction of ammophos, niciphos etc. is very useful.

3. *Nitrogen*—Nitrogen is the most important nutrient for plant growth. The growth of stem and leaf depends largely on this element. When the soil becomes deficient in this nutrient, plants turn yellow and remain stunted in growth. Nitrogen may be supplied in the soil by applying farmyard manure or commercial

fertilisers. Green manuring the soil with a leguminous crop, such as *dhaincha*, *matikalai*, cowpea etc. increases the nitrogen supply of the soil. For this purpose legumes should be grown in the soil and ploughed under as green manure as soon as they attain a good growth. This is the cheapest way to increase the nitrogen content of the soil.

4. *Lime*—Most of our cultivated crops generally enjoy a neutral or slightly acid soil, but when the acidity rises above a certain limit, crop fails. Wheat, cotton, mustard, pulses and fruit trees fail under acidic condition, while potatoes, tea and *arhar* grow very well in it. Application of lime neutralises the acidity of the soil and allows a free growth of plants. Sufficient application of ash also serves the same pupose. This is most important in Assam and parts of Bengal soils, specially in the old alluviums (Fig. 16) which are mostly acidic in nature.

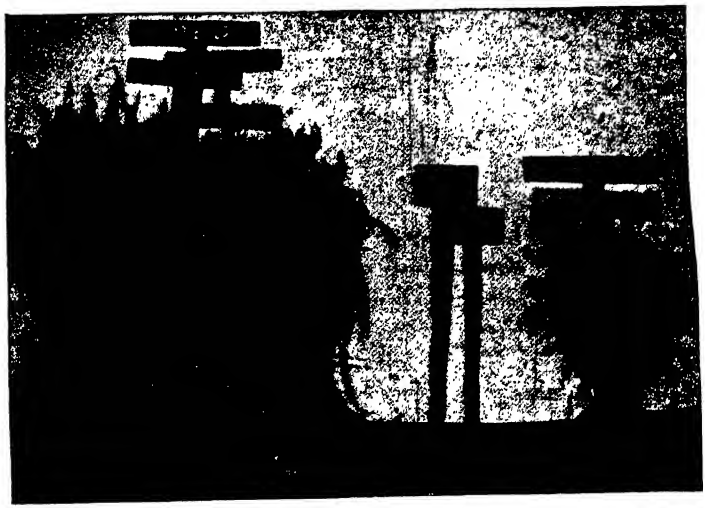

FIG. 16. Yield of oats in limed and non-limed plots, having a basal dressing of equal amount of cowdung and super-phosphate, Jorhat farm (after Meggitt).

Lime acts both as a food and a nutrient. It allows the growth of bacteria in the soil and so helps in the decomposition of organic material (humus) in the soil. It also helps in the flocculation of the soil particles and thus makes the soil more friable which helps in the drainage of surplus water.

Lime may be used in the form of burnt lime or crushed limestone. It is sold in the market in both forms. "Sylhet Lime" is

well-known. It is safe to use limestone in the field and as the effect continues for 3-4 years or more, it may be applied at the rate of 12-24 maunds per acre. About half the amount of brunt lime is quite sufficient for the purpose.

It may also be added here that over-liming should be avoided. Moreover, application of lime should be followed by manuring with green or farm-yard manure, as it sets in quick decomposition of organic matter in the soil and is liable to exhaust it.

5. Cowdung—Cowdung is the most easily available plant food. It contains nitrogen, phosphorous, potash and sulphur, and is a very good mixed fertilizer. The cultivator should know how to store it and use it. He should have a manure pit with a thatch cover on it. The cowdung with the left-over straw and litter should be put in the pit and composted there all the year round. It should be applied at the rate of 150-300 mds. per acre at the time of ploughing the field, (when decomposed well after a few months). It is a good source of supplying humus to the soil. Any refuse organic matter in cultivator's home may also be composted in the manure pit.

The Humus

The decomposed animal and vegetable matter in the soil is the humus, as stated before. The maintenance and increase of this humus content of the field-soil are the most important factor for crop production. The presence of humus in ample quantity in a soil means success; its lack means failure. This is particularly true in dry regions where the rainfall is not more than 30 inches. Humus effects the soil mainly in three ways:—

(i) *Physically*—Humus benefits the soil physically by increasing its water-holding capacity and bettering its texture. It also increases the warmth of the soil.

(ii) *Chemically*—Humus benefits the soil chemically by supplying gradually nitrogen, phosphorous and potash which are mostly needed as food for the plants.

(iii) *Biologically*—Humus benefits the soil biologically by affording food for micro-organisms and allowing them to grow freely in the soil.

In fact, humus may be taken as the very life and activity of the soil which is essential for a successful crop production. As commercial fertilizers are very costly and farmyard manure is

not quite sufficient, legumes should be grown and ploughed under to increase this humus content of the soil (Fig. 17). This can easily be done by growing them both in winter and summer, as need be. Moreover, if the cultivator fails to grow a legume, he may collect jungle leaves and trench them in the soil at leisure time which does not cost him anything.

It may also be mentioned here that the bacterial activity in decomposition of organic matter is best in dry and least in water-logged soils. The latter is quite common in the vast low-lying

FIG. 17. Dhaincha laddered and ploughed under Dacca Farm (after Meggitt)

inundated areas of Assam and parts of Bengal. When the air spaces in the soil are partly filled with moisture, the conditions are most favourable for the decomposition of organic matter, such as green manures. It is therefore advisible to grow them early and plough them under before the rains set in.

QUESTIONS :

1. In what form does the plant take its food ?
2. Name the plant foods that are sometimes wanting in the soil and explain briefly the utility of the three most important elements, required for plant growth.
3. State briefly how plant foods can be added to the soil ?

4. What is acidity in a soil and how can you test it ?
5. State the beneficial effects of lime. When is it harmful to crop plants ?
6. What causes the nodules in legume roots ? How do they benefit the soil ? Name the legumes that are commonly grown for green manuring purpose.
7. Which is the best time to grow a legume and plough it under ?

LABORATORY EXERCISES :

1. Plan out a manurial experiment in a small plot, divided into two parts. Apply manure in one and leave the other as it is. Then put in some *matikalai* or mustard and note the results.
   (1) Is there any difference in the growth of the plants in the two sub-plots, manured and check ? If so, why ?
   (2) Will the manure increase the yield of our field crops ? If so, why ?
2. Take a similar plot which is known to be acid. Lime one sub-plot and leave the other as a check. Sow some *khesari* or *matikalai* seeds and note the results.
   (a) Does the lime help better growth ?
   (b) How does lime effect the soil and the plant ?
3. *Take a few samples of soil* from a low land, a high land and a vegetable garden and test the acidity.
   (a) Which is most and which is least acid ?
   (b) Can you find any reason for this difference in acidity ?

CHAPTER VII

PROPAGATION OF PLANTS

Plants generally propagate from seeds and you, perhaps, know that most of our cultivated crops, such as rice, jute, wheat, barley etc. are produced from seeds. In the case of fruits and flowers there are artificial means of propagation by inarching, layering, grafting, budding and cutting. Experience has shown that fruit trees, when propagated from seeds, degenerate a great deal. It is to maintain the purity of the variety that such artificial methods are adopted. In fact, owing to continued propagation from seeds there is no recognised variety of mangoes and oranges in the Eastern Bengal and Assam.

Natural Propagation from Seed

In propagating plants from seeds, one should secure good seeds. They are to be sown in a plot of land which has already been prepared thoroughly. After sowing, seeds should be covered well with dirt and the soil, packed by an improvised soil-packer. A piece of flat board will serve the latter purpose.

In growing a crop from seeds, we must bear in mind the vitality, i.e., the germinating capacity of seeds. A good seed ought to germinate at least 90%. Seeds of our field crops, such as paddy, wheat, barley, maize, mustard and jute may be tested before they are sown in the field. The vegetable and pulse seeds that we get in the market, very often remain mixed with many weed seeds. A sample of pure seed should not contain other undersirable seeds. Attempt should always be made to obtain seeds from a reliable source.

Artificial Propagation

Many fruit and flower plants are artificially propagated, as described below :—

1. *Budding*—The process that involves in inserting a bud of one plant under the bark of the stem of another is called budding. It is a simple operation. In so doing, the cambiums of both the stock

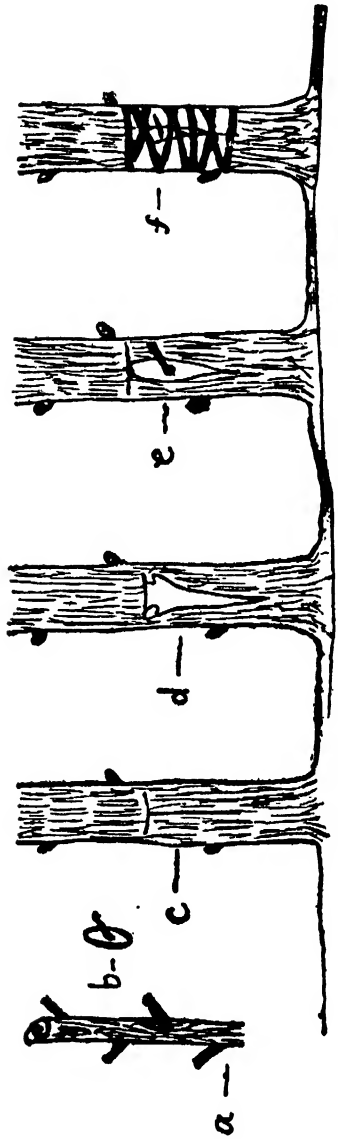

FIG. 18. *a, b, c, d, e, and f*, showing the process of budding.

and the scion, as they are called, come in contact with each other and make a joint. Budding is done in spring and summer, just at the time when the bark slips easily. Citrus fruits can easily be propagated by budding. In nurseries roses are propagated in the same way. The one important advantage in so doing is that hundreds of trees are propagated from one single tree, giving a distinct variety. Moreover, when budded on a stock, each one of the leaf-buds will produce an independent plant and will be ready to be planted in the garden in a year.

In order to bud fruit trees, a suitable nursery stock of the same family should be raised first. When the seedlings are about the size of a lead pencil, which is attained in a year or two, they are ready to be budded on. The operation consists of a T-shaped cut in the bark of the stock about 6 inches above the ground (Fig. 18). The bud is cut in the form of an eye from the branch of the selected variety and is inserted in the cut. As soon as the bud is inserted, it should be tied with strong but soft cotton or jute fibre. This will make the joint, which can be easily recognized by the green colour

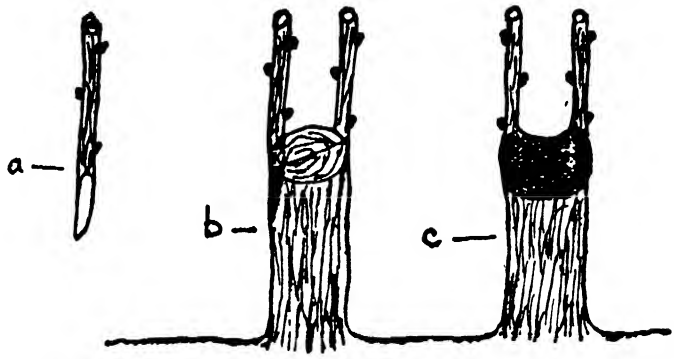

FIG. 19 *a*. Cleft grafting.

of the bud after a week, when the tie is removed. If the bud is set, the stock is to be cut off about 2-3 inches above it. When the bud grows about a foot high, the stock is again cut near the joint and the growing bud is tied to a stick. This bud is the future tree.

2. *Grafting*—Like budding, grafting is also used to propagate selected varieties of fruits. In this case too, the nursery seedlings are used as stocks and the branch of a selected tree is collected carefully so that it does not dry up. It is then inserted in the stock. There are several methods of grafting, of which the cleft and the whip grafts are mostly used.

(a) Cleft Graft—When the diameter of the seedling, *i.e.*, the stock, is 1-3 inches, cleft graft suits best. For this purpose the

stock should be sawed off clean and a cleft is made in it by a big knife or *dao* (Fig. 19a). The scion, on the contrary, should be cut in the form of a wedge and after prying the cut open by the *dao*, the scion should be inserted in such a way that the

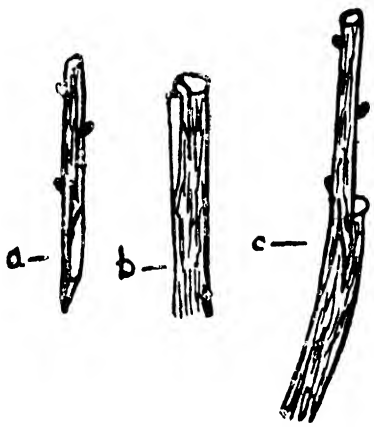

Fig. 19 *b*.—Whip grafting.

cambium, of both the stock and the scion come in contact with each other. If the stock is more than an inch in diameter, two scions can be put in. Then cover the cleft in the stock and the base of the scion with grafting wax, which may be made as follows :—

Melt the following over a slow fire for use in grafting :—

(i)	Tallow	1 oz.
	Bees wax	2 oz.
	Resin	4 oz.

This mixture should be stirred until it becomes light yellow in colour. It is then ready for use, when cold.

(ii)	Resin	1½ lb.
	Bees wax	4 oz.
	Linseed oil	4 oz.

Resin and bees wax are to be melted together and the linseed oil is to be poured slowly by stirring the material all the time. The wax is then ready for use. As the material is very sticky, use a little linseed oil to handle it.

(*b*) *Whip graft*—When the scion and the stock are of about the same diameter, whip graft will suit best. Both the scion and the stock are cut in the shape of a tongue and a cleft is made in the centre. The scion is then thrust in the stock. (Fig. 19b).

The joint is tied with jute fibre and then covered with wax. Wax cloth may also be used. This can easily be made by dipping strips of new *markin* cloth in melted grafting wax and then kept in the form of a ball. Apple, pears and guavas can be grafted in this way.

3. *Layering*—The process of layering is very simple. There are two ways to propagate by layering, which are as follows :—

(*a*) *Ground layering*—Ground layering can easily be made by bending a branch down after removing the bark wholly in the form of a ring or partly with a knife and covered with soil (Fig. 20 b).

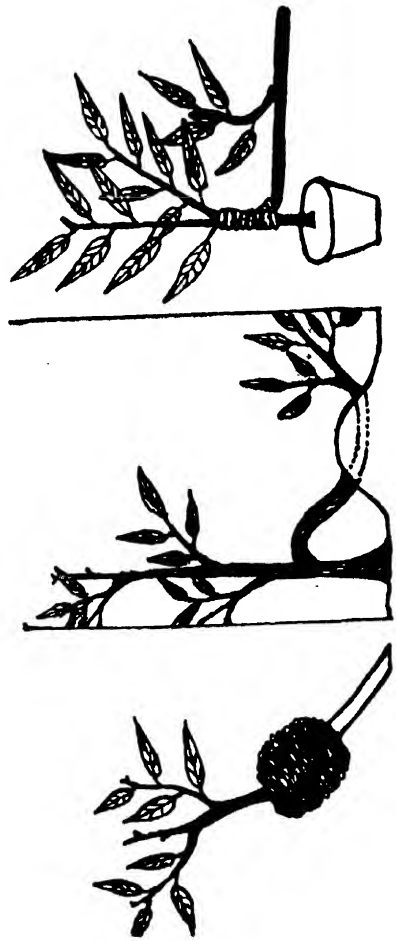

Fig. 20 c. Inarching.

Fig. 20 b. Ground layering.

Fig. 20 a. Air layering.

Adventitious roots come out in the covered part in two or three weeks. The branch can then be separated from the main plant and

planted in another place. Lemons, limes and grapes may be propagated in the same way. Moreover, in the case of some bushy trees when the base of the plants is covered with soil in the form of a mound, it induces rooting of the branches which may be separated later as root cuttings. This can also be done in apples, plums and guavas.

(*b*) *Air-layering*—Fruit trees can be propagated by air-layering. The selected branch used is partly covered by soil, mixed with cowdung and the part tied with jute fibre (Fig. 20 a). Before covering the part of the selected branch, the bark is taken out in the form of a ring with a knife which encourages the growth of adventitious roots. This is to be done in the rainy season. In case there is not enough rain, one should put an earthen water pot with a hole at the bottom plugged with jute fibre, thus allowing the water to fall in drops so as to keep it moist. After the roots come out, the branch is separated and planted. Mangoes, litchis, guavas etc. are air-layered in this way.

4. *Inarching*—Inarching is simply grafting by approach. This is commonly practised in growing mangoes. The operation consists of growing a seedling in a pot and then bringing it in touch with a scion of the desired variety. A thin slice is taken off both from the scion and the stock of equal diameter and they are then tied together by jute fibre (Fig. 20c). It is better to cover it with wax cloth or mud. After a month when they are united, the scion branch is severed from the parent plant and the young plant is kept under partial shade for about a month and a half and then planted in the orchard or the nursery.

5. *Cutting*—Plants may be propagated from cuttings of young woody stem, which has grown for a season. Grapes, roses, marigold, hibiscus (*jaba*) etc. may be propagated in this way. Cuttings may also be made from leaves, such as begonias and bryophyllum (*Patharchuna*). The latter will grow buds at every notch of the leaf, when it is put on the moist ground.

Cuttings should contain few leaves and must be trimmed at the apex. This reduces evaporation from leaves. Rose cuttings may preferably be put in moist sand under shade. When they get a good start, they are to be transplanted in the garden.

6. *Bulbs*—A bulb may be defined as a short underground stem where food is stored. Such a bulb is covered with scales and will give out roots from the base. The best examples are onion,

hyacinth, tulip and narcissus. The buds which grow from parent bulbs may be planted separately.

7. *Tubers*—The potato is the best example of a tuber which is a mere modified stem, where food is stored. Similarly, the tubers of dahlia can also be used for propagation. If you examine a potato minutely, you will see some depressions here and there. These depressions are the so-called eyes in potato tubers and are the real buds. They grow, when planted in the soil under favourable conditions.

QUESTIONS :

1. Why should you propagate some plants by artificial means and why not from seeds ?
2. How does the common *Kachu* (Arum) propagate itself ? Do runners send out buds and roots to form a new plant ? How ?
3. Why do you remove the bark to make an inarching ?
4. How would you proceed to make an air-layering in litchi and guava ?
5. What is the secret of succes in budding and grafting ?
6. What would be the best time for budding and grafting ? Why ?

LABORATORY EXERCISES :

1. Make a few cuttings of marigold, hibiscus and rose.
   a. How long does it take for rooting in each case ?
   b. Why are leaves and tops removed from cuttings ?
2. Plant a few potato tubers in a furrow two feet apart. Cut a sweet potato in 3 or 4 pieces and plant in a ridge in the same way.
   a. Note where do the buds and the roots come from in each case.
   b. From your study in (a) explain why potato is a tuber and sweet potato is a tuberous root.
3. Make a ground layering of lemon and lime.
   a. How long does it take for rooting ?
4. Make an inarching of mango.
   a. How do the stems get the joint ?
5. Bud a few orange seedlings and roses.
   a. What advantage do you get from budding ?
   b. Will the budded plant and the seedling produce the same type of fruits ? If not, why ?
6. Make a few grafts of tomato, apple or peach.
   a. Is it possible to improve the native pears of Shillong and Darjeeling by top grafting ?
7. Plant a few onion bulbs in a line.
   a. Where are the buds in a bulb ?
   b. Can you separate them for planting with advantage ?

CHAPTER VIII

IMPROVEMENT OF CULTIVATED CROPS

In dealing with the improvement of our cultivated crops, you should understand first the fundamental principles that underlie the phenomena of heredity and variation which are now summed up in the term Genetics. They are the two foundations on which rests the whole science of Plant breeding.

Genetical Relation

1. *Heredity*—Every individual living being, as a unit in itself, takes birth, grows, produces offsprings and dies. This is the natural law of life. As a result of reproductive activity of the existing living individuals, new progenies arise in a continuous succession. One of the most remarkable feature in this process is that "like tends to produce like" very closely. The offspring of a paddy plant develops into a paddy plant and that of the jute into a jute plant and nothing else. Moreover, a particular variety of paddy or jute will produce similar individuals of that variety. Even a specific character, such as colour or size in a plant or an animal is transmitted from the parents to the progeny for many generations. This resemblance to parents or ancestors is known as Heredity.

2. *Variation*—Although the hereditary resemblances in offsprings are so close, they are exactly not the same. Every one of you know for certain that in a group of brothers and sisters, no two are exactly alike. There is a certain amount of differences and each has some peculiarities of its own. In plants where the progeny are usually numerous, there often seems to be a closer resemblance between them than in animals. But further observation will show that considerable differences exist. These differences among individuals of a progeny, born of same parents, are known as Variations. This special qualification that every living individual possesses makes a plant or an animal more desirable than another and thus leads to the possibility of improving it by selection.

It is not infrequent to see new morphological types appear as bud variations in plants, especially those which are propagated

vegetatively as in deciduous and citrus fruits, grapes, potatoes and strawberries. Bud selection has received much attention in recent years to improve plants.

3. *Mutation*—When a large number of plants or animals is propagated, sometimes individuals suddenly arise with new characters, which when propagated purely give a new race. This spontaneous origin of individuals with new characters is called Mutation which is now ascribed to be the cause of diversity within the same species of plants or animals. Mutations in nature occur in many froms. They have been observed in seeds of evening primroses, carnations, chrysanthemums etc. In fruit trees bud mutation is evidenced by the production of nectarines in peach branches.

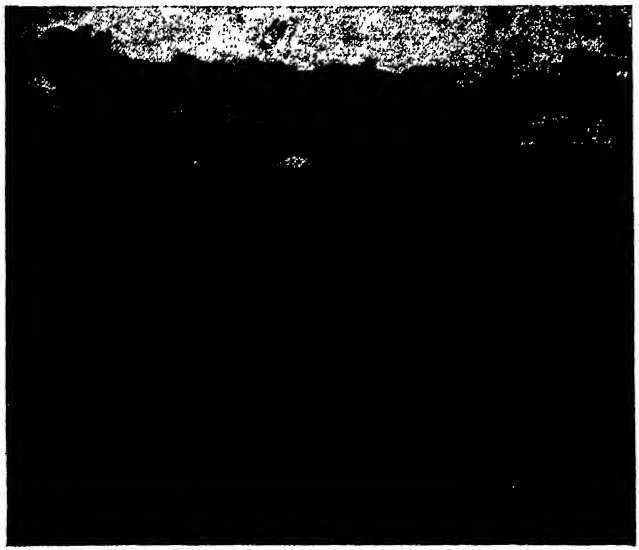

Fig. 21. Rice selection work at the Karimganj Farm, Sylhet.

4. *Breeding of plants & animals*—Practical breeders in Europe and America have long been working on the breeding of plants and animals and thereby achieved valuable results in improving a pure strain of wheat and cattle. The most important method in breeding is the selection or choice of a plant or animal for breeding which approaches the desired type.

In getting a desired type, selection may be applied to characters either with single or variable traits, such as size, shape, quality etc. As the extremes in such a case do not breed true, breeders always depend on the slower process of variation as is found in medium

individuals in a population with slight variation in getting the desired type. This method has given good results in obtaining many of our domestic varieties in plants and animals. The wonderful success in evolving new varieties, namely, spineless cactus, Burbank potatoes, plumcot etc. by Luther Burbank, the well-known plant wizard of America, depends on his skill in recognizing valuable varieties, occuring among a large number of offsprings.

Improvement of Plants

a. Selection—You all know that an ordinary self-fertilized crop such as paddy, jute, wheat, barley etc. often consists of several varieties which unless cross-fertilized, will consistently differ from one another from generation to generation in respect to their individual characters, such as yield, size and shape, quality etc. The plant breeder has to isolate the pure types first by growing the different varieties separately and select those types which possess such desirable characters that are lacking in others or are present only to a comparatively less extent. It is this selection that has made it possible to get Pusa wheat No. 12, Indra sail and Lati sail paddy, Kakya Bombai and Green Olitorius jute etc. (Fig. 21). In improving the sugarcane and the potato, one may select the most fully developed setts and tubers respectively from the particular plants and then grow them separately in small individual plots. When the crop matures, selection should be made from each plot for next season's planting and this will be continued.

Method of selection to improve a field crop, such as sugarcane or potato may be shown in the chart below.

1st year	2nd year	3rd year	4th year	5th year
Selected seed, plant or tuber.	10 plants selected plant	1/10 bigha 10 plants selected plant	Field crop 1/10 bigha 10 plants selected plant	Field crop 1/10 bigha 10 plants selected plant and so on.

From the chart you may easily understand that out of the selected seeds or plants, obtained by growing in the 1st year, 10 plants are to be selected and grown in the 2nd year. The seeds form the 2nd year will be enough to grow 1/10 bigha in the 3rd year, the yield of which in turn will be sufficient for a field crop in the next year. In order to continue the selection year after year, a plant is to be selected from 10 plants in the 2nd year's crop and thus continue selection from it as before.

If selection is continued in this way, one can expect to obtain a desirable variety after several years of patient labour.

b. Hydridization—It has already been stated that variations are the steps towards the improvement of plants and animals. This involves the method of selection which brings out this variation very slowly. On the other hand, cross-fertilisation induces the variation very rapidly. Successful breeders use the latter method to get the desired characters in a plant or animal.

FIG. 22. Arhar plants covered with cloth to induce self-pollination for pure seeds (Jorhat farm).

The process of cross-fertilization consists in transferring the pollen from one flower to the stigma of the pistil of another selected plant. The organs of flowers concerned in fertilisation are the stamen, containing the pollen (male organ) and the pistil, containing the overy (female organ). In many flowers these two parts are borne on the same flower, such as the mustard, pea and bean ; in others they are on separate flowers of the same plant such as the pumpkin, walnut and maize ; and in some they are produced in separate plants, such as the willow and the date palm. In those cases where the stamen and pistil are borne on the same flower, the stamen must be removed before the pollen becomes mature and sheds on the stigma of the pistil so as to prevent self-pollination. Moreover, in order to produce pure seeds by inducing self pollination, a plant is to be covered with a cloth bag (Fig. 22).

The parents that are used in crossing are called the first parental generation (P_1). The hybrid that is obtained from it is known as

the first filial generation, F_1 and the progeny of the F_1 generation is called F_2 and so on. From the F_2 generation pure types, resembling the parents come out in a certain number of individuals. By selection, isolation and cultivation from these pure types, one can get seeds with desired characters to serve the agricultural purposes.

QUESTIONS :

1. What do you understand by heredity, variation, selection, self-pollination and cross-pollination ?
2. How can you improve your paddy and potato by selection ?
3. Do you know of any method of selection adapted by the cultivators of your locality for any special crop ? If so, state the method ?
4. How can you improve your crops by cross-fertilization ?
5. Do you know of any known variety in sugarcane, paddy and jute ? If so, name them. How were they obtained ?
6. Are the ordinary bazar seeds good for sowing ? If not, why ?

LABORATORY EXERCISES :

1. Collect a number of mango leaves and measure the length of each in millimeters. Then form a skew curve to show the mode or the type of the majority. (Ask your teacher to help you).
   (a) Are there any two leaves of equal length and width ? If not, why ?
   (b) What does the mode show ?
2. Collect a *muti* or a bundle of paddy ears. Select the best one of uniform length with sound grains. Preserve it as a sample and if possible grow it separately.
   (a) Is selection of paddy in this way of any use ? If so, why ?
   (b) What would you do to keep up the purity of the preserved sample next season ?
3. Visit the Botanical Laboratory in an Agricultural Experiment Station, if possible, and note the methods of plant breeding, adopted there.

CHAPTER IX

THE PLOUGH

The cultivator must have a knowledge of his own soils, especially in relation to the climatic condition of the region. He must find out by his own experience and observation as well as that of his neighbours what crops are best suited to the different soils in his farm holding. He will have to plough, harrow and cultivate his land according to the soil and the crop he desires to grow. The purposes of these operations are :—

1. To turn the top soil down and with it manure and other organic materials that lie on the surface.
2. To loosen and pulverize the soil for better absorption of water.
3. To kill weeds and insects.
4. To aerate the soil for better bacterial growth and release of more plant food.
5. To dry up the top soil so as to form a mulch and conserve the soil moisture below.
6. To cover the seeds with dirt and facilitate root development.

Ploughing

The first requirement in the preparation of land is the plough. The Indian cultivator seldom knows anything better than his own time-honoured country-plough. Truly speaking, it is not a real plough, but a wedge-shaped wooden log to scratch the surface soil. It does not turn the soil upside down, but rather throws it out on both sides, which seldom fulfils the necessities of ploughing. Moreover, it does not go deeper than 4 inches in the soil and consequently fails to give any satisfactory result. But, in the paddy fields where the soil is generally soft and muddy such a country plough is good for puddling. Since it is not very effective in ploughing, the cultivator has to plough at least 4-6 times the

same plot of land before he can broadcast seeds or transplant seedlings. This means the wastage of a good deal of extra labour and time in repeated ploughings. If the cultivator would have been fortunate enough to get a good plough, he could save his time and labour.

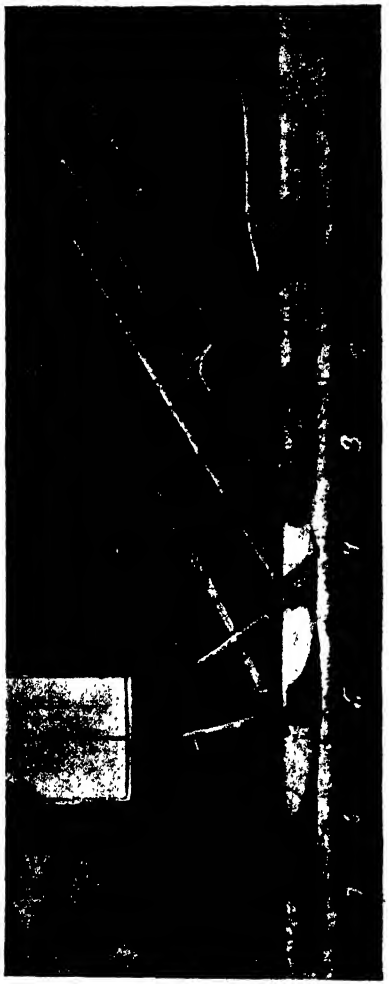

FIG. 23. Different types of ploughs (after Rajeswar Das Gupta, through the courtesy of Krishi Sampad).

1. T. W. plough
2. Hindusthan plough
3. Sibpur plough
4. Meston plough
5. Rajeswar plough
6. Country plough
7. Planet Junior.

Various kinds of improved ploughs are sold in the market, of which the Meston plough is lightest. It costs about Rs. 3-8 for the iron parts only which can easily be fixed in a country plough and can best be used to advantage in the paddy lands of Assam and Bengal. There are a number of other suitable ploughs, such as the Rajeswar, the Sibpur and the Hindusthan (Fig. 23). Moreover, there are a number of foreign and improved Indian ploughs which are

mostly found in Government farms. Of these, the Mould-board, the Turnwrest, the Rajah and the Punjab ploughs may be mentioned.

There is one important drawback in our country, especially in Assam and Bengal, for which our cultivators cannot possibly use the improved plough. This is the want of strong draught animals. The local bullocks that work in the paddy fields cannot always draw even the Meston plough, if the soil is not soft enough by heavy showers or first broken by a country plough. At present Bihar supplies a good number of plough bullocks both for Assam and Bengal at comparatively prohibitive prices. Unless the present state of the bullocks is improved, good ploughs can hardly be introduced in paddy and jute growing districts.

You may sometimes notice strong big bullocks in Government farms and in possession of well-to-do farmers of the country. These are all imported from up-country. A pair of such bullocks can easily pull a Meston plough, while two pairs are required to pull a Punjab or a Turnwrest plough that we see in Government demonstration farms. The latter are mostly required for a big scale farming, especially in the highland and hill sides.

In Western countries draft horses are bred for ploughing and cultivation in the field as well as for hauling heavy carts. A pair of such horses can easily work on a heavy plough, as mentioned above. Such draft horses are not produced in India for field work. Any effort in this line is highly desirable.

Time for ploughing—Most of our cultivated paddy fields are rather clay. Such soils are very difficult to plough when they are dry, as they puddle to hard clods. So, they are to be ploughed when they get wet by the monsoon rain. In case the rain does not come in time, the poor cultivator has to wait for a long time. This means a heavy loss to the cultivator, as he cannot get enough time to prepare his land properly for sowing and transplanting, especially the early paddy, the *ahu* or *aus*. This results in large cultivable areas, being left fallow every year. Moreover, where possible a paddy soil, which is mostly of clayey nature, should be ploughed right after harvest when the soil is still moist and some leguminous crop such as *matikalai, khesari* or gram should be grown. When baked hard, clay soil is very difficult to break. On the other hand, a sandy loam may be ploughed at any time. Such a soil is mostly found in the riparian tracts which are quite suitable for Rabi crops.

Most of our ploughing is done during the rainy season from March to July when the major portion of the monsoon rain falls. This affords a favourable condition for the growth of paddy and jute

which are the two staple crops of Assam and Bengal. But where the land can be prepared in winter or in spring, two crops can be grown with advantage. In this the cultivators of Assam should follow their brethren in Bengal and Bihar and thus improve their economic condition.

The best time for ploughing is winter, although it is really very hard to carry out the operation with the country-plough. If improved ploughs are used to break up the soil in winter from November to January, when it still retains moisture, it will give an opportunity to the cultivator to grow a rabi crop and prepare the

Fig. 24. Ploughing with a tractor (Government farm, Kanapara, Gauhati). (Photo by P. C. Khongwir).

soil again with the early rains for paddy or jute. The soil, thus prepared, becomes ready to absorb the first rain and can easily be prepared for the first paddy crop (*aus*) or the jute. In this way early ploughing after paddy harvest or the use of improved ploughs will give two crops which is really a great problem in Assam and parts of Bengal. So long as the cultivator does not get a chance to raise two crops in his field, there is very little chance to better his pecuniary status. This can only be attained with the introduction of improved machineries and better type of draft animals to work on them. Under present circumstances the introduction of motor tractors through the agencies of organised capital is worth considering in our country, especially for big scale farming. (Fig 24). Some of the private farms have already been using the machine power and they are partly successful in their enterprizes, while the common cultivator will never get the benefit of this twentieth century invention unless this is introduced by Zeminders, Co-opera-

tive and Agricultural Associations and other organized capitalists on pure business principles. Of late there has been failure in tractor cultivation in many places. This is mostly due to the want of a proper man to drive the machine and repair it, as need be. While buying a tractor, one should employ a trained man to do the work.

Depth of the plough—Except sandy soils, where the plant food remains in a few inches of top soil, ploughing should be deep and the depth should vary from year to year, *i.e.*, if it be 12 inches this year, it may be 8 inches the next and 6 inches in the third year. As with our cultivators, they plough at the same depth year after

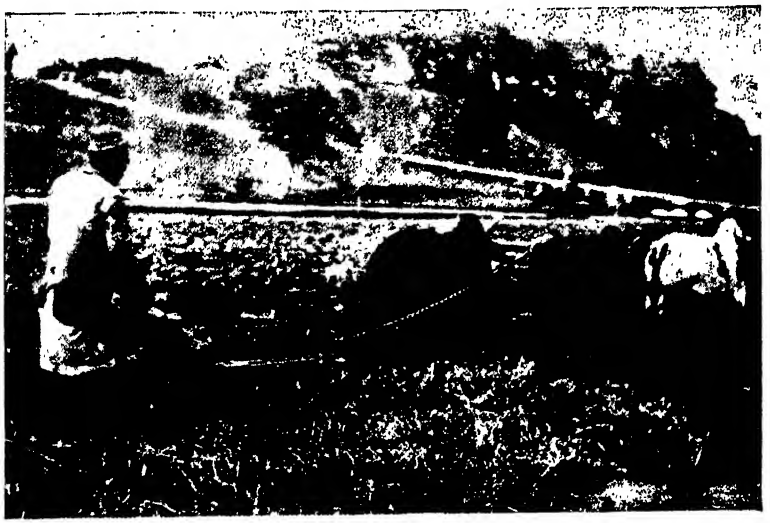

Fig. 25. Hillside ploughing with a turnwrest plough, Upper Shillong farm. (Photo by P. B. Choudhury).

year which causes a layer of hard bed, known as "plough sole," a few inches below the surface. You can find it out easily, if you drive a walking stick in a puddled land ready for sowing or transplanting which will not go beyond 4 inches in the mud. Gradually this hard bed becomes impervious to water and plant roots. It serves a useful purpose in storing rain water in paddy fields in higher areas where stiff clay soil prevails. However, deep ploughing is generally necessary for root crops, but for grain crops it is not advisable to plough deep every year.

Furthermore, deep ploughing in low-lying paddy lands, which are subject to flood year after year, is not necessary at all, as they get the annual silt deposit on the surface. But in higher levels, it

is very important for a successful crop, especially of *aus*, jute, sugarcane and potatoes. Similarly, in highland and hillside cultivation, deep ploughing should always be resorted to (*Fig. 25*).

In ploughing with heavy ploughs, the animals should be hitched right close to the plough, as in that case they will haul it better. Instances are not rare where carelessness on the part of the ploughman causes a failure. In a turnwrest or a mould-board plough the

Fig. 26. A disc harrow (copied from the catalogue of Messrs. Shahasrabuddi & Co.).

width of the furrow can easily be regulated by moving the clevis to the right or left, as desired. A properly adjusted plough will run smoothly and the bullocks can haul it without much exertion.

2. *Harrowing and cultivation*—The common country harrow does not serve very well the purpose of harrowing. It simply acts as a drag in the field. There are several types of improved light

harrows, sold in the market, which may be used to advantage. The home-made bamboo harrow will serve the purpose better, if provided with iron spikes. Improved disc harrows (Fig. 26) are necessary for a large scale cultivation to save time and labour.

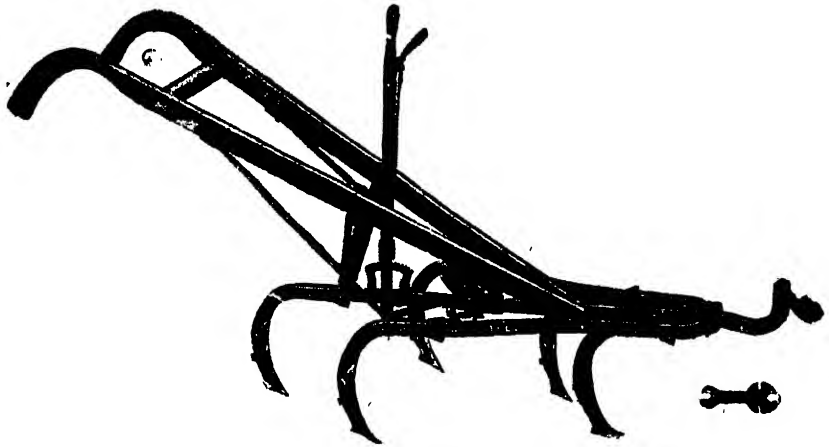

FIG. 27. A Spring-tyned cultivator (Copied from the catalogue of Messrs. Shahasrabuddi & Co.).

After the ploughing is over, it is better to run a cultivator. A spring-tyned cultivator (Fig. 27) serves the purpose very well. It removes the weed and levels the ground. Cultivation after a heavy shower loosens the soil which acts as a mulch to conserve soil moisture. There are many improved cultivators in the market. They may be used to kill weeds, pulverize the soil and conserve soil moisture.

3. *Packing the soil*—Packing the soil with a roller levels the surface by crushing the clods of earth. It makes the soil compact and allows the capillary water to rise quickly. It is very useful in sandy soils. It is advisable to run a harrow after packing the soil with a roller. This will make the soil loose so as to check evaporation.

QUESTIONS :

1. What is the purpose of ploughing and harrowing the field ?
2. What is the best time for preparation of soil ? What are the difficulties that are met with under our conditions ?
3. State the reasons why we should plough the field deep.
4. What are the difficulties that a cultivator meets with in ploughing his land ?

5. State briefly how tillage can conserve soil moisture in your field.
6. State briefly the effects of shallow preparation of the soil in our cultivated fields.

LABORATORY EXERCISES :

1. You may go to a Government farm and notice the different improved ploughs, harrows, discs, chains, roller and other implements and get yourself acquainted with the use of them.
2. If there be a motor tractor in your locality, go and see it, working in the field.

CHAPTER X

THE CATTLE

The domestic animals that help us in farming may be grouped under three main heads—(1) the cattle, (2) the sheep and (3) the hog. Buffaloes, cows and oxen are included in the cattle group, which are the great friends to our cultivators. The second group includes the sheep and the goat which supply a major portion of our demand for meat in the market. The hog supplies the demand of ham, bacon and lard. From the milk, supplied by buffaloes and cows we get the milk, ghee, curd etc. for our every day use. The draft buffalo and the bullock do the work of ploughing and hauling heavy carts both in the country as well as in the crowded towns.

Buffaloes

The buffaloes are water-loving creatures in their habits. They are very useful in cultivating the low-lying paddy fields in the rainy plains of Assam and Bengal. They are good feeders and do well without much care. A good many cultivators depend on them for the ploughing and the supply of milk. One buffalo can draw a plough. If properly trained, buffaloes are best suited to draw the heavy improved ploughs. Attempt should be made to improve them by breeding. A good many buffaloes are imported from Bihar every year and are mostly sold in the large fairs both in Assam and Bengal.

There are a few well-known breeds in India which may be briefly described as follows :—

1. *Murra*—These buffaloes are bred throughout Delhi, Sind, the Punjab and some parts of the United Provinces. They are very large animals, with deep wide rather short frames. The colour is usually jet black but occasionally white markings are met with. The horns are very characteristic of the type, being spirally curved upwards, backwards and inwards often forming a complete circle like the horns of a ram. They are very good milkers. A good

she-buffalo gives in her own habitat even up to 50 lbs. of milk per day.

2. *Jaffrabadi*—This breed has been named after the name of the district of Jaffrabad in Kathiawar. Both white and black animals are found. The most characteristic feature of the breed is the growth of horns which turn downwards and then curl up and grow rather in the opposite direction than that of the *Murra* buffalo. The she-buffaloes are good milkers and yield from 20 to 40 lbs. of milk per day.

3. *Surti*—These buffaloes are bred throughout Gujrat but especially in the Kaira district and Surat. These animals are found in the herds, belonging to *goalas* or milkmen in the Bombay Presidency. They are smaller in size than *Murra or Jaffrabadi.* They are of mixed colours—black with white markings, grey and albino. The she-buffaloes are fairly good milkers and a good Surti buffalo will give from 15 to 30 lbs. of milk per day.

4. *Deccani*—These are common buffaloes of the Deccan and Kankan. They are very similar to the Surti in general conformation and colour but are somewhat larger in body. They have larger horns which curve downwards and backwards, reaching to the shoulder. This breed is more hardy than the Surti or the *Jaffrabadi.* They are fair milkers, when well-bred and cared for. A good she-buffalo of this breed gives from 10 to 16 lbs. of milk per day.

5. *Bangor*—The local buffaloes of Assam are called the Bangor (Fig. 28). They are moderately large-sized animals. The male buffaloes are good draught animals and are more efficient and useful to cultivators in low-lying paddy tracts than bullocks. Many cultivators depend entirely on them for ploughing and supply of milk. The she-buffaloes are fairly good milkers in comparison to local cows and yield from 12 to 20 lbs. of milk per day. The Bangor buffaloes of Assam may be developed to a magnificient breed of animals by proper breeding and management.

6. *Manipuri*—The native habitat of this breed is Manipur. The animals are stronger than the Bangor and consequently are good for draught purpose. They are rather darker in colour than the Bangor with horns, running more or less regularly to form a cone-shaped structure. There are two bright gray rings on their neck. The animals of this breed are naturally more clean than the Bangor, but they are susceptible to diseases and do not fare well in hot climate. The cross between the Bangor and the Munipuri has been found to be better suited to the climate of Assam and Bengal.

Oxen

The cattle of Assam and Bengal are very poor in comparison to those, we find in the up-country. This is due to the humid climate, lack of proper care and dearth of fodder; the latter two being the most prominent causes for the deterioration of our cattle. Although law provides for grazing grounds in every locality and taxes are accordingly paid by the cultivators, the area reserved is rather small in consideration to the increase in number of cattle and consequently there has always been a difficulty in getting sufficient green stuff to feed them. The apathy of the people to take care of the cattle, especially to supply them even a little salt, water and straw after a day's grazing, has been a common habit in Assam.

Fig. 28. Bangor buffalo (after unknown)

This is one of the main causes of deterioration of Assam cattle. Consequently, the draft bullocks have deteriorated so much in the country that they can hardly pull a country plough unless the land is softened by heavy rains. It is for this reason, hundreds of bullocks are imported from up-country every year and are sold in the markets of Assam and Bengal at high prices, ranging from Rs. 150/- to Rs. 300/- a pair. Unless care is taken to breed these draft animals in the province, this problem could never be solved. Attempt should be made to improve the draft animals by crossing their females with larger and stronger bulls from outside, so that the progeny may acclimatize easily and serve the purpose of

ploughing and cultivation. Besides, the cultivators should improve their grazing areas, stack straw, produce fodder for cattle and preserve the same in well-kept silos. They should also take the advice of the Veterinary Assistants and save their cattle from diseases and death.

Milch cows—The scarcity of good milch cows and good milk is keenly felt by every body in Assam and Bengal. The main reason for this is the want of proper care of the cows and good fodder, as is mentioned in the case of draft animals. Besides, the

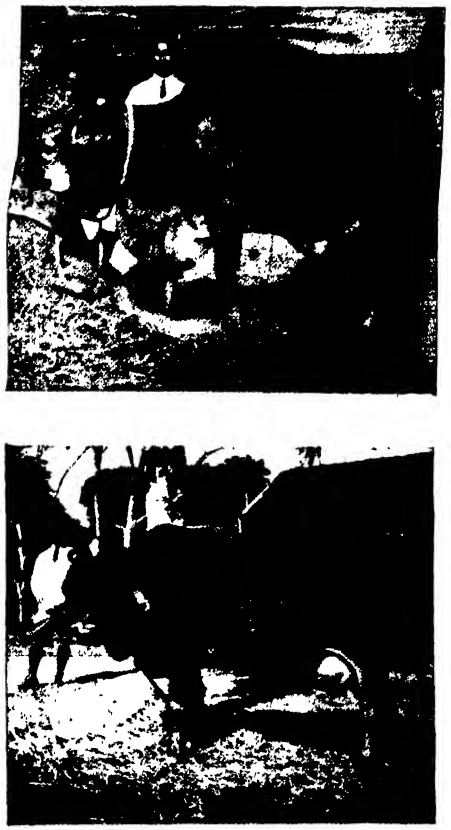

FIG. 29. Montgomery bull and cow
(Photo by P. B. Choudhury).

humid climate, which we live in, also affects the health of the animals a good deal. For this reason care should be taken for better housing and sanitation.

Breed—There is no definite breed by which the cattle of Assam and Bengal may be designated. But, when we consider the cattle

of other parts of India, we meet with individual breeds adapted to particular localities. They may be briefly described as follows :—

1. *Montgomery or Sahiwal breed*—This breed originated in the Montgomery district of the Punjab. They are very good-looking animals and the colour varies a great deal—dark red, lemon and white grey or spotted cattle being fairly common. The average daily yield of milk is from 15 to 30 lbs. The cows are medium in size, short-legged with fine clean-cut heads, fairly short horns, thin necks, fine big bones, small feet, long and thin tails. The long and heavy dewlap is characteristic. The udder is large and well-shaped with regularly placed teats (Fig. 29).

They have been sent to many parts of India and acclimatized well under different conditions. In the Ferozepur military Dairy the two best cows have given 13,717 lbs and 12,242 lbs. of milk in one lactation.

2. *Hariana, Hansi or Hissar*—This is one of the leading dual purpose breed of cattle in India. It comes mainly from the Hissar district in the Punjab. The breed is also found in the districts of Rottock and Gurgaon. The colour varies from silver white to dark grey. The head is fairly long with large expressive bright eyes and upright horns sloping slightly backwards. The head of these cattle is always carried high, giving a very graceful appearance. The udder is usually small, compact and well set up under the flanks with moderate sized teats. The milk veins are prominent. The average daily yield varies from 15 to 30 lbs. in their native habitat. Very good draught bullocks are found in this breed.

3. *Sindhi*—This breed of cattle is found in adjoining places of Karachi, Hyderabad and Sind. (Fig. 30) This is perhaps the smallest amongst the Dairy breeds of India, the cows weighing from 600 to 800 lbs. and the bulls 900 to 1100 lbs. This is one of the purest breeds that exist in India today and great care is taken to keep the breed pure. Most of the Sindhi cattle have a deep red colour with occasional white spots or patches. The cows are very mild in temper. Sindhi cows are good milkers, giving as much as 20 to 30 lbs. of milk per day in their native habitat. This breed has been introduced to improve the local cattle of Assam and Bengal.

4. *Tharparkar*—This breed comes from the districts of Tharparkar in Sind. The colour of the breed varies from silver white to very light grey. They are fairly good milkers and good draught

FIG. 30. *a.* Sindhi Bull (Photo by R. C. Wordfod).

FIG. 30. *b.* Sindhi cow. (Photo by R. C. Wordfod).

animals. Experimental breeding of this type for dual purpose is carried on at the Imperial Cattle breeding farm, Karnal and as a result, this breed has been introduced to a limited extent to improve the local cattle of Assam and Bengal. They are comparatively bigger and heavier than the so-called Assam and Bengal cattle. The average yield of milk per day is 10 to 20 lbs.

5. *Kankrej*—This breed of cattle is found within the limits of Baroda—Mahikantha Agency. Some Kankrej cattle are bred in parts of Ahmedabad and Kaira districts. The Kankrej cows are white or silver grey in colour with black points, whereas the bulls are usually darker. Their horns are thin and take a spiral curve upwards and backwards and present a graceful appearance. They are good draught animals with long and thin legs. The cows of this breed are generally poor milkers.

6. *Amritmahal or Mysore*—This is a distinct trotting breed of Southern India. The cows of this breed are poor milkers. In disposition they are wild and unruly and even impatient to the presence of strangers. They require several months' kind treatment to handle them properly. The bullocks are moderately large, strong and useful in drawing carts.

7. *Malvi*—The Malvi cattle of Malwa (Guzrat) have been bred pure for a very long time. The predominating colour is pure white, though grey or silver grey specimens are common. They are medium in size and adapted for all kinds of works, especially ploughing, carting and lifting water from the well. They are generally very shapely in appearance, having the frame wide and deep but not very long.

8. *Gir*—This breed originates extensively in the Gir forests and hills in the south of Kathiawar. The cattle of this breed may be classed as medium sized. The Gir cattle exhibit a very characteristic uniform appearance and are remarkably true to the type. The cows are chiefly noted for their milk qualities. The male stock is useful for ordinary road or field work, but it is slow and never suitable for heavy draught and requires careful shoeing on account of its soft hoof. The colour varies and broken colour as roan is common. The good milkers in their own habitat yield 20 to 30 lbs. per day and the period of lactation continues for 8 to 10 months.

9. *Ongole or Nellore*—This breed of cattle is bred in the North-eastern districts of the Madras Presidency and forms the main milk breed of Madras. The prevailing colour of Nellore cows is pure white, whereas broken colour of black and white is not uncommon. The average yield of milk is about 10 to 15 lbs.

10. *Kasi*—This breed originates in the Muttra district and includes Merwari cattle of Ulwar and Bharatpur states. The animals are of moderate size, somewhat smaller than Hariana. The common colours, met with are white and grey, being comewhat darker at the shoulder and neck, although broken colour of black and red may be seen. The bullocks of this breed are valued greatly for all agricultural draught purposes and especially for quick trotting.

11. *Khari*—Khari in the Lucknow division is one of the most important cattle breeding centre. The cows of Khari breed are very poor milkers and in fact are very rarely milked. When compared with the bulls and the bullocks, they appear to be very small and inferior-looking animals and it is surprising to find what a sturdy and handsome male progeny they are able to produce.

The bullocks of this breed are noted for speed, endurance and symmetry and are greatly valued on account of their usefulness for ploughing and other agricultural purposes.

12. *Taylor or Patna breed*—This breed was established in Bankipur, Bihar in about 1856 by Mr. Taylor from local breed, crossed with English bulls. They are medium in size and are good milkers. They are good looking animals with different colours of brown, red, black, and broken colours. They are suited to Assam and Bengal conditions. They were brought in the Upper Shillong farm in 1898 and have since been doing very well in the hills. They

Fig. 31.

have spread in the Khasi hills and the present good condition of cattle in Shillong is mainly due to their introduction. They are well suited to hill and plain conditions. (Fig. 31).

13. *Pahari or Hill cattle*—The Pahari cattle are very active and move about very cleverly over the different hillsides in search of grazing. The chief colours, met with are black, brown, red and broken colours. They are fine looking small animals with silky hairs. They are short-legged and short-horned. As a rule neither the hump nor the dewlap is very well developed in these animals.

In temperament these animals are somewhat wild. The males are used for ploughing purpose. The cows are very poor milkers. In different localities these Pahari cattle are known by different names as Sri cattle in the Darjeeling district, Maurangia in Nepal, Bhutia in Bhutan boarder, Manipuri in Manipur and so on.

Besides these there are other breeds in India, such as the Dhamri, Krishna valley, Dangi, Khillari, Nimar breeds and so on.

The cattle generally found in the plains of Assam and Bengal do not belong to any fixed breed. They are a mixture of different cattle, with all the characteristic meagre qualities that are possible in ordinary bovine animals (Fig. 32). None of them are good

Fig. 32. An Assam cow with calf.
(Photo by P. B. Choudhury).

milkers, but when properly fed and taken care of, they give 2—3 seers of milk. They are perhaps the smallest in size, especially in Assam, and may be improved by crossing with better strains, as stated above.

It may also be mentioned here that no attempt has yet been made in India to breed the beef-cattle, for which there is a demand in the market. Attempt should be made in this line to serve the commercial purpose of supplying the right kind of beef in the market.

Value of good breed—The cultivator should always try to get an animal of good breed, because no poor scrub type of animal will

give him a good profit either in milk or as a draft animal. Pure-bred animals should always be our aim. Among the different breeds, as described above, one should bear in mind the two-fold purposes, *viz.*, the milk type and the draft type, that will suit our cultivators best. A good many improved foreign breeds have been introduced in India, although they are not as yet so successful. The foreign milch cows which are found occasionally in government dairy farms or in possession of well-to-do private owners and are used in crossing with the country breeds, are Jersey, Holstein, Ayrshire (Fig. 33) Herefordshire, Shorthorn, Aberdeen Angus and the like.

Fig. 33. An Ayreshire bull, Shillong (Photo by P. B. Choudhury)

A good dairy cow can easily be recognised from its appearance. It should be wedge-shaped or angular in form from the head to the tail. The head should be small and the mouth large. The udder should be full and swollen. Milk veins should be large and extended towards the breast with numerous branchings.

The scarcity of fodder in Assam and Bengal is very marked. The cultivators should grow at least one crop of fodder to maintain their cattle. Stacking of rice straw is not enough and even that is so poorly done in Assam that it is really deplorable to see its wastage. In order to keep up their strength, the milch cows need some sort of nourishing green feed and unless it is grown, it is not possible to supply it only by the scanty pasture grass. Moreover, concentrated feeds such as *matikalai*, oilcakes, rice bran etc. should be added to the daily ration of milch cows without which it is not possible to get sufficient milk.

Cattle-breeding—To improve the cattle of Assam and Bengal our main efforts should be to supply breeding bulls and control the breeding by stray bulls, which should not be allowed to move freely in a herd. Young males should be castrated before they attain maturity. If necessary, law should enforce this practice.

Cross-breeding among the suitable Indian breeds and between the foreign and the Indian breeds has been tried a good deal in many parts of India and as a result, a number of strains have been produced to suit our Indian climate. The Rangpur government dairy farm has established a strain which has become successful in many parts of Bengal. The Patna Taylor breed is another example, as mentioned before. However, the pure Indian breeds, as stated before, are unsurpassable in their own habitat by any others cattle either foreign or cross-bred.

Diseases of cattle

The cattle suffer from a number of contagious fatal diseases, of which the following are important :—

1. Rinderpest (*Basanta* or *Guti*).
2. Foot-and-mouth disease (*Aishu* or *Badla*).
3. Hæmorrhagic Septicæmia (*Galaphula*).
4. Anthrax (*Tarka*).
5. Black quarter (*Badla*).

1. *Rinderpest*—The symptoms of this disease are :—

   a. Fever, followed by heavy discharges from eyes, nose and mouth.
   b. Swelling of gums and under surface of the tongue with white small spots.
   c. The affected cow suffers from constipation and then diarrhœa and dysentery, showing blood and mucus in the dung.
   d. Pinheaded ulcers in the gums and the buccal membrane of the mouth.

Treatment—Internal administration of Potassium permanganate 2-4 drams in a quart of water is often effective.

Treatment—For constipation use one chhatak of Epsom salt.
For fever one-half tola of Quinine is useful.
For dysentery use—

Chalk	.. 2 tolas	} to be mixed thoroughly.
Catechu	.. 1 tola	
Opium	.. ¼ tola	

2. *Foot-and-mouth disease*—The symptoms of this disease are very well recognized from the blisters on feet, gums and the tongue. Foamy salivary secretion also comes out from the mouth.

Treatment—(1) For washing mouth.

a. Alum .. 1 tola
Water .. ½ seer

b. Potassium permanganate solution (1 grain in a quart of water).

(2) For dressing the sores in feet.

Tar .. 4 tolas
Turpentine .. ¼ tola
} to be applied on the sore.

3. *Hæmorrhagic Septicæmia*—The cattle in this case get a very high fever with swelling on throat and tongue which causes difficulty in swallowing and breathing. The swelling is hard, hot and painful. The affected cattle may die in a few hours.

4. *Anthrax*—It is rather difficult to find out the symptoms of the disease. In some cases the animal becomes restless with high fever and discharges from nose and mouth, while in others diffused and painless swellings in throat or neck are noticeable.

5. *Black quarter*—The affected animal becomes rather lame and slow to move, followed by a swelling in some part of the body, specially the upper part of the thigh, the neck or the shoulder. The swelling is at first hot and painful and later on becomes cold and soft as if distended with gas, such a condition distinguishes this disease from Hæmorrhagic scepticæmia.

Preventive measures—The last named diseases are rather difficult to differentiate and so one is often mistaken for the other. There is no special treatment for them. As the diseases are contagious, it is better to take necessary steps to control the same instead of trying remedial measures. However, the following measures should be adopted :—

1. The affected animal should be isolated at once in a separate shed in an out-of-the-way place.

2. The cattle shed should be disinfected with boiling water and quicklime. Application of phenyle water is also effective. The dung and dry litter of the infected animal should be burnt or buried.

3. The dead animal should be buried deep and should not be allowed to be skinned.

4. The Veterinary assistant should be informed for advice, specially in the case of rinderpest. The whole herd should be inoculated and people in the neighbourhood should work on a co-operative basis, without which it is not possible to control the disease.

The sick animal may be treated as follows :—

1. Keep the animal clean and dry in a dry place. Use phenyle water in case of foot-and-mouth disease to wash the feet and paint them with tar.

2. Supply soft food, such as boiled rice, gruel and soft grass.

3. Supply tepid warm clean water.

4. The convalescent should not be allowed to mix with the others before a month has expired.

Diseases caused by other external parasites—Animals, suffering from the attack of lice, ticks, etc. should be washed daily with phenyle solution (1 in 100 parts of water). Care should be taken to burn all the crusts and fallen hair to prevent the spread of contagion. Animals which are in weak condition, suffer mostly from the diseases caused by external parasites.

Internal diseases of cattle—Calves often suffer from the attack of intestinal worms. For this, their dung should be examined regularly. As a preventive, an emulsion of linseed oil and turpentine should be given in a dose at an interval recommended by a veterinary surgeon in due consideration of the age of the calf. The use of 2 ozs. of a weak solution (1%) of copper-sulphate and nicotine-sulphate will be very helpful.

The sheep and the goat

The foot hills and *tilas* of Assam and Bengal are suitable for raising the sheep and the goat. It is not required to grow any fodder crop for them, as they can feed on the land which has already been pastured by cattle. A good number is imported from Bihar every year to supply the demand for mutton, (Fig. 34) both in Assam and Bengal.

Sheep may be raised for both wool and mutton, and the goats for milk and mutton purposes. There are different breeds of sheep in India of which the Bikaneer breed suits well in the hills of Assam

and Bengal. The Angora goats are the most famous milkers and their wool is as soft as silk. They are suited to the hills and may be tried for profit.

FIG. 34. Sheep grazing, Jorhat.

The milk goats of up-country, called *Ram Chhagal,* are good milkers and they thrive well in the plains. Considering the demand of milk in the market and the scarcity of fodder, it is profitable to raise these big goats to supply the milk. Moreover, it may also be stated that such an industry is sure to give a good profit, provided care is taken to save goats from the depredation by wild beasts.

The hog

The hog is seldom raised in India by the cultivators, although the sweepers as a class raise them for profit. They are highly prized for their ham, bacon and lard. When hogs are properly cared for and fed well, they will give a satisfactory profit at a very low cost. The hill tribes rear them for profit.

The domestic hogs have originated from their wild ancestors. They have been developed in Europe and America by breeding. No distinct breed is known in India except the two common types, the black and the albino. The latter is very rare and has a great demand for breeding purposes.

GENERAL QUESTIONS :

1. Name and describe briefly the different breeds of Indian cattle.
2. What are the uses of cattle in a farm?
3. How do the cattle improve the soil of a farm?

4. State briefly the characteristics of a good milch cow.
5. Is it profitable to keep sheep and goats? How?
6. Is it profitable to maintain a herd of scrub cows or a few good ones? Why?
7. Name the prominent cattle diseases that are prevalent in your locality.
8. How can you save your cattle from epidemic diseases, such as the foot-and-mouth disease, anthrax and rinderpest?
9. How do you judge a cow from outward appearance?
10. Why should you castrate the stray bulls and introduce good ones?

LABORATORY EXERCISES :

1. Take a trip to a neighbouring dairy farm, if possible, and note the following :—
   - *a.* The breeds of cattle.
   - *b.* The milk records of cows.
   - *c.* The bulls used for breeding.
   - *d.* The bullocks.
   - *e.* The feeds and the feeding of the cattle.
   - *f.* The silo and the silage, used for the cattle
   - *g.* Draw a diagram, stating the different parts of the body of a cow with the help of your teacher.
   - *h* Draw the diagram of a cattle shed.

CHAPTER XI

THE FODDER

The cultivators of our country mostly depend on the natural grasses in the pasture land for their cattle. As there is not enough pasture land for grazing cattle, it is really a problem to maintain them. It is for this reason that those who own cattle must produce some sort of fodder for them ; as the paddy straw, they generally get is not enough for the purpose. Where there is a good deal of waste land or a forest near by, the question of growing a fodder crop may not arise, but in the thickly populated districts of Assam and Bengal, every cultivator should have an area reserved for growing fodder.

Fodder crops may suitably be included in the plan of rotation of crops in the field and if wisely carried out, one will find it really profitable to grow them. You may remember that however poor the cattle may be, if they are properly fed and taken care of, they will be really very serviceable both as milkers and as draft animals. Every cultivator who has half-a-dozen cattle should grow a fodder crop in addition to the grass pasture available in the neighbourhood of his homestead.

The cultivators of Assam and Bengal are not accustomed to growing a crop for fodder purpose, but with the present scarcity of pasture land, they are realizing the difficulty and it is expected that in near future they will adopt the practice of growing fodder for cattle. In growing a fodder crop, one should note the following few points :—

a. The fodder crop grown must be cheap, palatable, digestible and not injurious to the cattle in any way. As for example, if *jowar* is fed before it flowers or when it is stunted in growth, it may produce hydrocyanic acid poisoning. The tops and leaves are quite free from this effect and may be fed without any danger.

b. A fodder crop, grown must be quick growing so that it may not interfere with regular cultivation of food crops.

c. The outturn of a fodder crop must be very heavy.

d. The fodder crop, grown should require less cultivation, manuring and care.

e. The crop should be good for preservation as silage or hay without much loss of feeding value.

Of the fodder crops, those that are easily grown and relished by cattle are grasses, legumes, cereals and root crops. All of them may be grown both for soiling and silage.

Grasses

1. *Guinea grass*—It is an introduced grass and is only found to be grown in government farms (Fig. 35). It should be grown

Fig. 35. Guinea grass, ready for cutting, Jorhat farm.

on a higher level where the flood water does not affect the crop. It is easily propagated from root-cuttings. If 4 or 5 root-cuttings are planted in a hole, they become ready for cutting in two or three months. It is a perennial grass. If properly manured, it will give 5-6 cuttings in the rainy season and 2-3 cuttings in winter.

2. *Napier grass*—The Napier is also a good perennial grass like the Guinea, although it is somewhat coarser than the latter. The method of its cultivation is the same as that of the Guinea grass. Both of them are highly relished by cattle and have proved to be successful in Assam and Bengal.

3. *Para grass*—The Para grass, recently introduced from Ceylon has proved to be a quick-growing grass in low-lying water-logged areas where the Guinea or Napier grasses will not grow. This is also a perennial grass with a trailing habit, standing 2-3 feet of water. It is liked by cattle.

Legumes

1. *Matikalai*—In a silted soil, just after paddy or jute is harvested and the ground is still wet, one should broadcast *matikalai*. It will grow without any care. If it can be saved from the ravages of stray cattle, it will be very useful not only to supply fodder to cattle but to enrich the soil. In old alluviums, if *matikalai* is sown early with an application of lime and manure after preparing the land properly, it will give a good crop. Clay soils should be avoided for broadcasting *matikalai*, as they dry quickly and crack to form clods. If desired for green manuring purpose, *matikalai* may also be sown on highlands at the beginning of rains in April or May.

2. *Cowpea*—Cowpea will grow well, if it is sown in April and May for fodder purpose. It does not require much care and will thrive on higher levels. It will grow in winter season provided it is sown early in October. It will do well as a rotation crop and will serve the purpose of enriching the soil.

3. *Peas and Khesari*—Peas and *khesari* may be grown to supply green fodder to the cattle in dry season, when grasses become scarce. For this, the land should be prepared and the seeds should be sown early in October. In the inundated areas they may be sown broadcast after paddy or jute. They do well as a good rotation crop like cowpea. If desired, the dried straw may be bailed and reserved for future use. They do well, when grown with oats for soiling and silage.

4. *Lucerne and berseem*—Lucerne and berseem, especially the latter, have been found to be successful in drier parts of India. They are not suitable in Assam and Bengal. Lucerne may be sown in October and if not water-logged, it will give several cuttings until the heavy rains set in, when it will die. It is grown to a certain extent in the vicinity of Calcutta for race horses and the green material is sold at a very high price.

Cereals

1. *Wild rice*—The wild rice, commonly called *Jhara dhan*, which naturally grows on the margin of *beels* and ditches, serves

as an excellent fodder for cattle in the inundated areas of Assam and Bengal. It may well be used as a silage.

2. *Cultivated rice*—During the dearth of fodder and grazing in the rainy season, some of the cultivators cut the tops of growing paddy plants and feed them fresh to the cattle. A portion of the land may be alloted for the purpose by every cultivator, which will give two or three cuttings during the rainy season and a low outturn in grains. The *asra* (shallow water aman) paddy is suitable for this purpose.

3. *Oats*—Oats are only grown as a winter crop and can also be grown for fodder. Oats and peas can be sown together which will serve the purpose better. It should be sown in October after a thorough preparation of the soil. Oat straw may be stacked like paddy straw. Wheat and barley may also be grown as fodder where opportunity permits, especially in riparian tracts.

4. *Maize and jowar*—Maize and *jowar* are summer crops of higher areas in Assam and Bengal. They may be used as green fodder and silage. Their cultivation is not difficult. With an application of farmyard manure, they will give a flush of growth in a short time. Cowpea may well be sown with *jowar* or maize.

Root crops

Radish, sweet potato, turnip and knol-kohl may be grown as fodder for cattle. For this purpose a deep cultivation is needed and sufficient cowdung should be applied. The leaves will supply a good green fodder, whereas the roots can be sliced and boiled before they are given to the cattle. They will relish them most when a little salt is added. The root crops will do well as silage.

Silo

Green fodder, such as *jowar*, maize, sugarcane tops etc. may be preserved in a fermented condition in a specially made container, built either above or below the ground. This is known as *silo*. It may be built of wood, brick or re-inforced cement concrete, the last being the best. The final product that is prepared from the green materials, put in the silo pit is called silage. Besides, *jowar* and maize coarse grasses such as *bata* or *barota, kasha, jhara dhan* (wild paddy) may also be used for silage. The materials may be cut, if necessary, and then filled into the container by trampling under feet. This will be ready for feeding the cattle in six months. Silage is always liked by cattle and it increases the milk flow.

The pit silos of Shillong have been successful for the last 30 years (Fig. 36). They can be made on a slope in a higher level

even in the plains where the rain water does not enter into the pit by seepage. Wooden, brick or cement silos are advisable in the

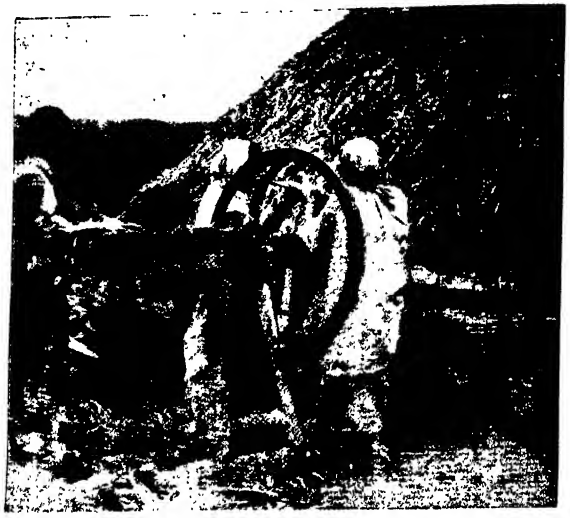

FIG. 36. Using a chaff-cutter to fill a pit silo with maize, upper Shillong farm. (Photo by P. B. Choudhury).

plains where attempts are made to keep dairy cattle on a big scale for profit.

QUESTIONS :

1. What is meant by fodder? Is there any necessity to grow it? State briefly how you can grow fodder for your cattle.
2. What fodder crops should be grown in a lowland which is inundated by floods during the rains? What fodder is suited to highland which does not go under water?
3. Name some fodder grasses that may be profitably grown by the cultivators in your locality.
4. What is silo and silage? What is their utility in a cattle farm?
5. How can you improve your pasture land?
6. Name a dozen wild fodder grasses that grow in your locality. Are they useful? How?

LABORATORY EXERCISES :

1. Collect a dozen wild grass samples that are found in the fields and pasture lands. Preserve them in paper pads and note their utility as fodder.
2. Take a trip to a government farm and see the way in which the cattle feed is preserved in a silo.
   a. What are the fodder grasses, used for silage?
   b. Examine the silage and state what transformation has occurred to the fodder grass, put into the silo.
   c. What are the best conditions for a silo?

CHAPTER XII

THE MILK

Milk is the main food for the child and the invalid. It must be obtained pure. If the milk is contaminated, it will produce disease in children. Milk is a good medium for the growth of many disease-producing bacteria or germs, which are very minute organisms. For this reason only boiled and warm milk should be fed to the children, as is generally the custom.

Before buying a cow, one should find out whether she is sound and healthy. It is unwise to buy a diseased cow, as it will spread the disease amongst others. Such a cow, if purchased, should be kept segregated until properly cured.

Whether a cow is profitable or not can best be tested from the butter fat of its milk. The fat remains floated in milk in the form of small globules like an emulsion, which can be seen under the low power of a microscope. A centrifugal milk tester will give the butter content in milk. Better quality of milk will make better quality of butter and *ghee* (clarified butter).

Composition of milk—Milk is a secretion from the mammary gland of the cow. It is a mixture of water, fat, sugar (lactose) and mineral matter. The major portion of the milk is water, in which the fat globules remain floating. The following is an average composition of cow's milk :—

Water	.. .. ..	87.0%
Protein	Casein & albumen	3.3%
Fat	.. .. ..	4.0%
Carbohydrate (Milk sugar)	..	5.0%
Mineral matter or Ash	.. ..	0.7%
		100.0%

Leaving aside the amount of water, there is 13 % of total solid matter in milk, which gives the food value.

2. *Vitamin*—It has recently been discovered that milk contains a substance called vitamin, which is essentially a component of protein. It is this vitamin that is most needed for the development of the body. Although the vitamin is found in other foods, such as meat, tomato etc., its main supply to children comes from milk. Besides, the ash content of milk contains the organic calcium which is needed for the proper formation of bones in very young man and animal. For this reason children, who do not get sufficient milk in childhood, often become rickety and are more liable to many infectious diseases. It is really a luxury to give milk to the adults when milk is so scarce. It should liberally be given to children and the invalid.

3. *How to obtain pure milk*—As our life in the beginning depends on a liberal supply of pure milk, we should try our best to obtain it in plenty. The following few points should always be remembered in production of pure milk :—

(1) No one should keep a diseased cow, especially a tuberculous one. Such a cow, when found out, should be segregated carefully and kept under the treatment of a veterinarian.

(2) Care should be taken to segregate a cow, suffering from *foot-and-mouth disease* and anthrax. One should call *a veterinarian to treat it.*

(3) The cows should not be sent out to graze with other cattle and allowed to drink water from a ditch or other *dirty pools.*

(4) The dairy house should be kept clean and a man, suffering from a disease should not be allowed to milk cows.

(5) Milking should be done in clean milk pails with a clean rag-cover on it. The milker should wash his hands before milking.

(6) The cow-shed should be dry, well-ventilated and well-lighted.

4. *Transportation of milk*—The milk supply in the towns of Assam comes from the *khutis,* situated far in the interior of the country (Fig. 37). They are owned by professional Nepali grazers who sell their milk to the *goalas* for town supply. In Bengal the milk supply is also entirely in the hands of milk dealers, the *goalas.* It is a pity that even in the heart of the city of Calcutta, there is no standard in milk distribution, although attempt has recently been

made to supply pure milk in bottles. In order to prevent the spread of diseases and also check the dilution of this savoury liquid

FIG. 37. A Nepali Khuti, Kamrup. (Photo by unknown).

by pure tap water, strict laws should be enforced. The open milk pails of the *goalas*, covered with date palm leaves, always invite the flies and deposition of dirt and germs of diseases. This should be considered a crime. The milk pails should have suitable covers which are available in the market.

The milk distribution should be organised on business principles by intelligent men on an improved system. Returnable bottles with easily removable card-board caps holding one seer, half seer and quarter seer of milk should be introduced. Only pasteurized milk should be distributed. In Calcutta a company supplies pasteurized pure milk in bottles. This should be the case with every town in India.

Ordinarily milk contains various kinds of bacteria, causing fermentation, of which the lactic acid bacteria are the most important which cause the curdling of milk. Various disease-producing germs also find their way into the milk, except the tubercle bacilli which come out with the milk from a tubercular cow. These bacteria or germs can be easily killed by heat. When the milk is boiled at temperatures from 150° to 165° F., most of the growing bacteria or germs are killed and the milk will not sour for 36 to 46 hours. This process is called "pasteurization". In pasteurizing milk, arrangements are made to cool it down rapidly to 50° F. or below, otherwise a cooked taste prevails.

Milk can also be subjected to high temperatures of 212° to 240° F. for an hour for three successive days for safe keeping. This is called "Sterilization". But the main defects in this process lie in the fact that it gives a very bad cooked taste to the milk, burns the sugar and destroys a part of the vitamin content. This is undesirable and consequently pasteurization is generally followed.

At present the municipal milk supply of Calcutta has improved a great deal. The *goalas* should be brought under absolute control of sanitation. The municipal organization in every town is responsible for the distribution of such a poor milk in the town market. Proper organization in milk supply is of utmost importance. It is an opportunity for private businessmen to start a dairy farm for profit near every town to supply pure milk. Co-operative dairy farm is also welcome. It is the bounden duty of the municipality, the district and the local boards to help an organisation in such an honest effort.

5. *Milk by-products*—A number of by-products is made from milk such as (1) *ghee* (2) butter, (3) cheese, (4) *rabri*, (5) curd, (6) *khir* (7) evaporated milk, (8) condensed milk and (9) milk powder. There is always a great demand for these in the market. The demand of the evaporated and condensed milk, cheese and milk powder is met mostly by foreign countries and this unnecessary imports can be stopped provided well-equipped factories are started in suitable centres with a sound capital under expert management.

(1) *Ghee or clarified butter*—The most highly prized by-product in India is *ghee*. This is commonly made by churning the ripened milk in a large earthen vessel by a bamboo churn. The churning separates the *makhan* or fat, which is then brought to boiling in a caldron. The water content is then evaporated and pure fat is left behind. In Assam and Bengal owing to the scarcity of milk, a very limited quantity of pure *ghee* is produced. Formerly, it was taken as a common ingredient for every day meal, while at present it is used sparingly as a luxury. As our Indian dishes are low in animal fat, it should be used more freely. It is really a pity that owing to the lack of any law against adulteration, this *ghee* is seldom found pure and is very often mixed with vegetable oils. This should be prevented by law. The *ghee*, obtained from the cow milk has a better flavour than that from buffalo and is sold at higher prices.

(2) *Butter*—Butter-making has become a prospective business at present and it is only recently that individual dairy and businessmen are making butter in large towns, making a good profit. It is sold in lumps, wrapped in wax paper and also canned for distant markets. It is for this reason that the imports in canned butter have been checked to a large extent. The method of butter-making may be stated as follows :—

a. *Separating the creem*—Our *goalas* churn the milk in the primitive style and sell the *makhan* or cream to small butter-making factories. They handle the cream so

roughly that the butter, made therefrom, is mostly contaminated. It is for this reason that such a butter becomes rancid in a few days. To avoid such troubles, the factories should have their own cream separator (Fig. 38).

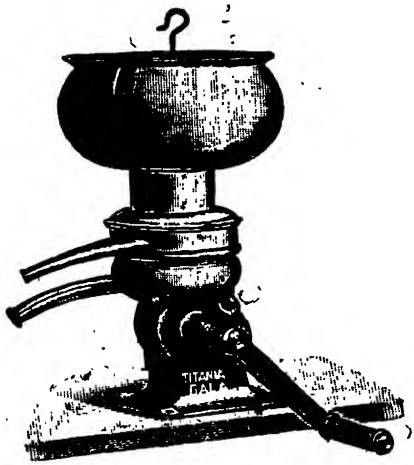

FIG. 38. A cream separator.

There are several types of cream separators in the market. At present some of the *goalas* are using such cream separators with advantage.

b. *Ripening the cream*—In order to facilitate churning, the cream is allowed to ripen, i.e., to sour overnight. The repening process also gives a better flavour to the butter. The chemical action that makes the sweet cream sour is due to a bacterial growth, known as the lactic acid bacteria. A starter is always better for souring the cream, which is commonly called *shacha*. Rennet tablets are also obtainable in the market for ripening the cream, which gives a better result.

c. *Churning the cream*—There are various kinds of churns, sold in the market, but barrel churn is a common one. The churn is made half-full of cream, having a temperature of about 60° F and that is why it suits best in a cooler climate as that of Shillong or Darjeeling. It is then worked by a rocking device. This is continued until the butter inside collects in small clusters. The butter milk is then to be drawn out and the butter is to be rinsed in water 2 or 3 times. It is salted by rocking the churn and

then the barrel is allowed to stand for half-an-hour to let the salt dissolve.

d. *Working the butter*—The working of the butter is the pressing of the material in a convenient apparatus to take the water out and mix the salt thoroughly. It is a short operation and if continued for a long time, the butter becomes greasy.

e. *Packing the butter*—In Shillong and Darjeeling, butter is moulded in blocks and then wrapped in parchment paper, so as to make them attractive. If desired ½ ℔ and 1 ℔ carton boxes may be obtained from the Calcutta market to pack the butter in attractive blocks. In such a case the use of a refrigerator is essential.

For distant markets butter is generally packed in tin cans, which are easily obtainable in Calcutta with accessories. Rim-sealed tin cans with a Burpee can-sealer are best. In preparing the butter for sale, one should always take extra care for labels.

It is always better to colour the butter, as it becomes more attractive. The standard colouring matter in the market is the anatto seed colour which is entirely harmless.

(3) *Cheese*—Different varieties of cheese are sold in the market, each one being made in some special process. There are both hard and soft cheese. The Swiss cheese belongs to the former, while the Roquefort cheese, the latter. The ordinary *chhana*, sold in the market, is called the cottage cheese. Fermenting bacteria, moulds and enzymes play an important part in cheese-making. The cheese may be made as follows :—

After the milk gets ripened, i.e., soured, it is slowly heated to a temperature of about 100° F. Rennent tablets diluted in water are to be mixed so as to get the best coagulation of casein, but ordinarily lemon or tamarind juice is used to serve the purpose. By the action of rennet or sour juice, the milk gradually thickens to a solid mass. This curd is then cut in small pieces and allowed to remain in the whey. Again the temperature is raised, the whey is removed and the matted curd is then cut into blocks. They are minced and salted.

The cheese is then bagged and placed under an wooden press to take out the rest of whey. It is then washed and pressed for a day. The cheese is next covered by cloth and left for ripening. The process takes about two to six months. The flavour of cheese is developed during the curing process.

(4) *Rabri—Rabri* is mostly found in the Calcutta market. It is made by boiling the milk over slow fire and collecting the scum on the edge of the caldron. The sweetened scum (*swar*) is sold as Rabri.

(5) *Curd*—Curd is the thickly fermented milk, caused by the action of lactic acid bacteria, as is generally done by the house-wives.

(6) *Khir—Khir* is the evaporated milk thickened to a thick consistency. It is made both from whole and skimmed milk.

(7) *Evaporated milk*—Evaporated milk is a foreign tinned product and is manufactured in factories. It is a mixture of milk and cream evaporated to about one-half of its original volume in a vacuum evaporator. It is then sealed in tin cans and sterilized.

(8) *Condensed milk*—Condensed milk is also manufactured in factories. It is produced by evaporation in a vacuum evaporator with sugar and without sugar. Both kinds are put in sealed tin cans. For these purposes, the milk should be produced under the best sanitary conditions possible.

(9) *Milk powder*—In manufacturing the milk powder, the milk is brought to a dry condition by an artificial method. Although it may serve the purpose of milk after being dissolved in hot water, the product does not taste like milk. However, it is considered to be an inferior form of milk and should not be given to children.

QUESTIONS :

1. What is the composition of milk and what are its uses ?
2. What diseases are liable to be carried by milk ?
3. How can you get pure milk-supply in a town ?
4. What by-products can be made out of milk ?
5. What is a bacterium ? How does it come in the milk ?
6. State methods of pasteurising the milk. Why should it be practised by milk-suppliers ?

LABORATORY EXERCISES :

1. To test the effects of clean and dirty milk :—Put some sour milk (curd) in two dishes. Then scald one in hot water and leave the other as it is. Pour in some fresh milk for souring in both and leave them covered under a dish.
   (*a*) Which sours first and why ?
   (*b*) What causes the souring ?

2. *To test the effects of boiled milk* :—Boil some fresh milk and put in a bottle which has already been scalded with hot water. Put fresh milk in another bottle. Cork the bottles and leave them aside. Notice the keeping quality of milk in the two bottles. Which sours first? Why?

3. Visit a dairy farm, if possible, and note the methods used to get clean milk.

   (*a*) Do they wash the milk cans and buckets with hot water? Why?

   (*b*) Why does the milker put a piece of thin cloth over the milking bucket?

   (*c*) Does he wipe the udder with a clean rag? Why?

   (*d*) Get yourself thoroughly acquainted with the use of a Lactometer, Centrifugal Fat Tester and Cream Separator.

CHAPTER XIII

THE POULTRY

Every cultivator ought to have some kind of domestic birds both for pleasure as well as for profit. Generally poultry includes fowls, ducks, geese and pegions. They do not cost much for their up keep and are always much liked by children.

Among these domestic birds, genrally raised by the people, fowl is the most profitable. You might have noticed that poultry mostly feed themselves. If they are properly housed and taken care of, they will bring a decent income. There is always a demand for eggs and fowls in the market. For this purpose, one should try to get pure-bred fowls, as they will supply more eggs regularly. They thrive well in a dry climate. Except Calcutta and the hill stations of Darjeeling and Shillong, imported pure-bred fowls are not seen very much in Assam and Bengal.

1. *Types of breed*—There are four types of fowls, each embraching several breeds, *viz.*, (1) Egg breed—the Leghorns and the Minorcas; (2) Meat breed—the Chittagong and Brahmas; (3) General purpose breed—the Light Sussex, the Rhode Island Reds, the Wyandotte and the Plymouth Rocks; and (4) Fancy breed—the Bantams. Except the Chittagong breed, there is no distinct Indian breed in Assam and Bengal that is worth mentioning (Fig. 39). The common fowls are a mixed poor group and are small in size. Their egg-laying capacity is very low.

The pure Chittagong breed is best for the climate and the soil of Assam and Bengal. They are less liable to disease and serve the dual purpose of both meat and eggs.

2. *Housing*—The cultivators seldom care to provide a good house for their chickens. They are generally found to be couped up in a small neglected corner of an out-house or cattle shed. It is not a very rare case to find them roosting on branches of small trees. This is always detrimental to the thrifty growth of the birds. A poultry house should be built up in such a way that there is enough space to accommodate them comfortably (Fig. 40).

There should be shelves (*machans*), baskets or some other device for the hens to lay eggs. The house should be dry and well-ventilated, and kept clean every day. It is always better to spread

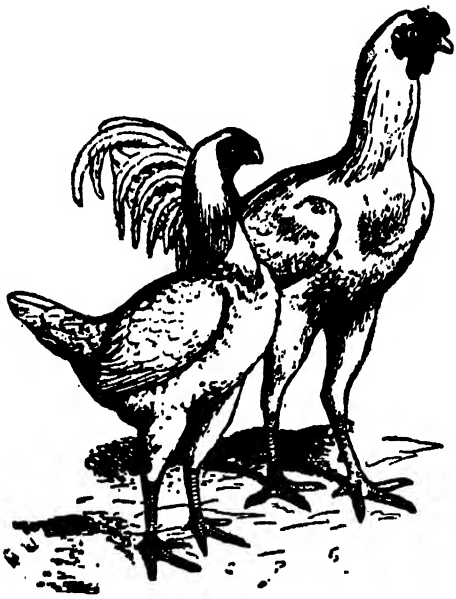

Fig. 39. A pair of Chittagong breed (After Isa Tweed).

sand on the floor, as they like to stay on it. Each fowl requires at least 2 sq. ft. of floor space and a house, (7′ × 12′), will do for 25 hens.

Fig. 40. Poultry House, Shillong.

In building a poultry house, you should always select a dry place. A porous soil with sufficient sand and grit in it is preferable. In the hill sections where the winter is severe, it is better to choose a southern or an eastern slope, as the birds require plenty of sunshine. Small shade trees should be planted in the yard or at suitable corners so as to give them enough shade in hot summer.

Generally, fowls have a very bad habit of scratching the soil and laying eggs in the bushes. They also damage vegetable patches and are a nuisance to neighbours. For this reason they should be fenced. Ordinary 2 inch mesh wire-netting serves the purpose very well. With a little labour a good bamboo fencing can also be made to advantage. The fence should be about 6 feet in height. Live wooden posts, such as Kapila (Mellolus philippensis), Paiia mandar (Frithrina indica), jarul (Lagerstrœmia) are suitable for the poultry run, as they give partial shade which is needed for the birds especially at noon time. As hawks and crows prey on small chickens, it is better to put a few strong wires, bamboo or cane strips lengthwise and crosswise on top over the whole length of the poultry run.

3. *Feeding*—Poultry should be fed carefully, especially when they are enclosed in a run. They sholud be supplied with meals three times a day. For this, rice bran, barley, maize, oat, *matikalai* and matar meals are very good. They are also to be supplied with some kind of greens such as cabbage, turnips, potatoes, radish etc. There are a lot of materials in the kitchen refuse which should be given to them. If the poultry yard is divided into 3 or 4 parts and small patches of *matikalai*, cowpea, *matar*, oats and paddy are grown, they will supply the greens throughout the summer and winter.

4. *Sanitation*—Fowls should have a constant supply of clean water. The water pan is to be put under a shade and should be cleaned every day. In case there is an outbreak of chicken cholera (*gutti*), the diseased birds should be separated and a little powdered sulphate of iron should be put in the drinking water.

Small bamboo baskets or kerosene-tin boxes may be fixed on the wall for brooding purposes. These are to be partially filled by soft straw. If one runs the business on a commercial scale, he can have a set of trap nests which is the best comfortable device for egg-lying or brooding hens. While brooding, the hens should be fed at least once a day.

Poultry yard should be kept scrupulously clean. Ordinary cultivators, often under a wrong notion that every dirt and filth can

supply food to fowls, neglect the proper cleaning of yards. This practice largely accounts for the diseases, found among fowls.

5. *Incubator*—By means of an artificial incubator, (Fig. 41) you can hatch your eggs without sitting hens. It is really very handy if you know how to use it. It takes 21 days for the eggs to hatch, as is ordinarily the case with sitting hens.

FIG. 41. A good hatch in an incubator (after Lemon and Kingshore).

6. *Caponizing*—The system of caponising (*khasikaran*) fowls is very profitable. One should learn how to do it. It will bring a double price for a fowl.

7. *Diseases*—Poultry suffer badly from various diseases, such as chicken pox, cramp, cholera, diarrhœa and gapes. In general these diseases are mostly caused by uncleanliness, lack of adequate food and shelter, and exposure to excessive heat or cold, which make the birds lose their vitality and strength. Drinking polluted water and eating decayed vegetables and animal matters and also fæces are to blame for their origin. In any case, a sick bird should be separated and treated. Unless one is used to handle the birds, one can hardly detect the exact disease. An experienced eye will at once pick up a sick animal and then treat it as prescribed in a poultry book. It is always better to recourse to prevention than cure.

Snakes and mongoose are two enemies to the chicken. A few drops of carbon bisulphide should be dropped in any hole that is found in the chicken house or in the yard. It is extremely poisonous and inflamable and so should be handled with care.

Hints on poultry keeping—If you take up poultry as a business, you should not only choose your breeds, but you should try to improve your flock of fowls by a careful consideration of the following :—

1. Select healthy, strong, pure-bred hens from which you shall have to collect eggs for hatching.
2. Keep the poultry house dry, clean and well-ventilated.
3. Sell poor hens and non-layers, as they are not profitable to keep.
4. Keep an eye on your flock for an attack of cholera. In such a case always segregate the suspected fowls.
5. Take special care of the diseased birds.

Ducks, geese and pegions—Ducks and geese can easily be raised provided there is a pond for them to swim where they will get most of their food. They generally feed on grass, small oysters and insects. Duck eggs have always a demand in the market.

Pegions are really profitable for anyone living near a town. The squabs have a great demand in the market. Packing boxes may be provided to them with partition, but for a large flock they should be provided with small nests in a house. Paddy, *matikalai*, mustard seeds and ground maize will be good for their feed.

QUESTIONS :

1. What do you mean by poultry ?
2. Is it profitable to raise poultry ? Why ?
3. What are the current prices of fowls and eggs in the local market ? Does it signify that there is a demand for them ?
4. Do you keep any fowl, duck or pegion ? If so, what does it cost you and what do you get from your birds as profit ?
5. How can you improve your stock ?
6. How can you say that an egg is sound ?
7. How can you detect a chicken suffering from chicken cholera ?
8. Why should the poultry be provided with sand and grits ?

LABORATORY EXERCISES :

1. Learn from some practical man, if possible, how to caponize fowls.
2. If there be a poultry farm near by, go and note the following :—
   (1) How to run an incubator.
   (2) How to test eggs.
   (3) How to size eggs.
3. Draw the diagram of the poultry pen with the help of your teacher.

CHAPTER XIV

FIELD CROPS

Among the field crops that are grown in our country cereals, pulses, oil seeds, fibres and sugar are important.

I. Cereals—Paddy, wheat, barley, maize and *jowar.*

II. Pulses—*Arhar,* gram, *matar, khesari, musuri, matikalai* and *mung.*

III. Oilseeds—Mustard, linseed and sesamum.

IV. Fibres—Jute, cotton, rhea, sunn-hemp and flax.

V. Sugar—Sugarcane and date palm.

Cereals

1. *Paddy*—Paddy is the most important staple crop in our country. It is grown mostly in the old and the new alluvial tracts, especially in the inundated areas of the Brahmaputra and Surma Valleys and the low-lying delta land of Bengal. The varieties that are grown are numerous and may be classified under three heads, namely, (1) *aus* or *ahu* (summar and autumn paddy), (2) *aman* (winter paddy) and (3) *boro* (spring paddy). The *aman* generally includes the *sail* (transplanted *aman*), *aman* (deep water *aman*) and *asra* or *bao* (shallow water aman).

Of these *aus, asra* and *aman* (deep water paddy) are sown broadcast from March to May. Of these the *aus* is harvested from June to August and the *asra* and the *aman* in November and December. The *sail* or *sali,* on the other hand, is transplanted from June to August and *boro* from November to January and their corresponding harvesting seasons extend from November to December and March to April respectively. Occasional sudden floods cause a considerable damage to *boro* and *aus* crops and sometimes cause an entire failure of *aman* (deep water paddy) both in Assam and Bengal.

a. *Soils*—Various types of soils both high and low are adapted to the cultivation of paddy, but it does best on clay soils, underlaid by a clay layer to retain moisture permanently.

b. *Preparation of land*—In growing a good crop of paddy, the the land should be thoroughly prepared. At least 5-6 ploughings

with the country plough and harrowing with a ladder (*mai*) are necessary to bring the soil to a fine tilth for broadcast *aus, asrá* and *aman* and a good puddling for transplanted *aus* and *sail*. *Aus* and *asra* are also sown broadcast on the puddled soil. The *boro*, which is transplanted in the silted soil on the margin of *beels*, does not need much preparation except puddling by trampling of cattle and men.

Ordinarily the land is prepared after the early rains soften the soil enough for the country plough to work it. The best time for the preparation of the land is winter, just after the crop is harvested, after which the soil is baked too hard for any country plough to work on it. If properly done, such ploughing and cultivation give an opportunity to grow a rabi crop or a green manuring crop of *mati-kalai*, cowpea or *dhaincha*, as need be.

c. *Broadcasting*—Ordinarily *aus* and *aman* paddies are sown broadcast in the field. After the preparation of the land the seed is sown evenly at the rate of 8—10 seers per bigha. A seed-drill can best be utilized in the dry land cultivation to save about two-thirds of the seeds sown. This is rather unknown to our cultivators. However, practice makes the hand set well in this work. The field should be lightly ploughed with a country plough followed by a laddering (*mai*) as soon as the seeds are sown so as to cover them well with dirt. A good shower at this time is very favourable for good germination. Irrigation from a *kaccha* well or ditch is also helpful.

In some places of the low-lying riparian areas in Assam and Bengal the cultivators broadcast both *aus* and *aman* together. One advantage of this practice lies in the fact that in case one crop fails owing to flood or some other cause, the other may succeed well.

d. *Seed-bed*—Except the broadcast paddy the transplanted paddies, viz., transplanted *aus, sail* and *boro* require a seed bed which should always be made on a higher level preferably near the homestead and fenced well. For this, the land should be ploughed well and then 4—5 feet wide beds made. The seed should be soaked in water for about 36 hours for germination before sowing in seed beds. In the meantime the soil should be puddled well and the germinated seeds sown. It requires about one to one and a half maund of seed per bigha which is good enough to cover about 10—20 bighas of land. If there is sufficient rains at the time, no watering is necessary. But in case drought occurs, beds should be watered well. Seed beds should be well-manured with cowdung at the rate of 150—250 mds. per acre. But this depends on the richness of the soil.

e. *Transplanting*—When the seedlings are about a month old, they are ready to be transplanted in the field. Before uprooting the seedlings, the cultivator should see that the land is thoroughly ploughed and is ready to be puddled. Up-rooted seedlings will keep well for 4—5 days provided they are put in bundles under a shade. The seedlings may well be transplanted 6″—9″ apart in *aus* and *sail* respectively and only two seedlings should be put in a hole. In case of late transplanting in September, 4—5 seedlings per hole may do well, as there will be no chance of much tillering. But, however, the best time of transplanting is from the middle of July to the middle of August when most of the rainfall occurs in Assam and Bengal (Fig. 42).

f. *Weeding*—In growing broadcast *aus* or *aman* it is always necessary to weed the field with a small hand-weeder, the *nirani*. If that is not possible for excessive rains, the field should be harrowed once when the seedlings are about 6″ in height, which will kill the weeds partially and thin out the seedlings. Unless there is standing water in the field, it is difficult to check weeds. So hand-weeding is necessary to get a good crop of *aus* or *aman*.

g. *Value of good seed*—The cultivator should always use selected good seeds obtained, from a reliable source and preferably from the government farms and keep his favourite varieties pure. For this purpose he may have a small plot of land for seed only. He may select his own seeds by hand from his field. He should grow only one or two high yielding varieties which will save his labour and give him a better profit. A change of seed, when available from a reliable source, is desirable every third or fourth year.

h. *Manures and fertilisers*—Of the manures and fertilisers that have been tried in the soils of Assam and Bengal, the application of farmyard manure and bonemeal responds very well to paddy. The use of *dhaincha* as a green manure often gives an increased outturn. Cultivators should try to use either of them, so as to recuperate the soil fertility, especially in high lands. Moreover, in places, where water hyacinth predominates, the cultivators will harvest a better crop, if they trench it under which will cost them an extra labour only.

i. *Milling of paddy*—The milling of paddy by the country *dhenki* is really a tedious and time-killing process, although this is the mainstay of many widows in the villages and *dhenki* rice is highly prized. At present a good number of rice mills have been established both in Assam and Bengal. For this purpose pure and uniform paddy grains are mostly needed.

FIG. 42. Transplanting of paddy, Jorhat.

The cultivators, especially those who supply the local paddy mills, should look forward to grow varieties that have a good milling quality, as they always fetch a better price.

j. *Straw*—Paddy straw is one of the main fodder for cattle, especially in the low-lying villages by the river banks during the rains when the pasture land goes under flood water. Straw should be cut at the base after the harvesting of paddy and stored properly for cattle. One should always stack the hay on a bamboo *machan* with a pole in the centre. The burning of straw in the field is a poor practice, as it is harmful to the soil. The use of straw for thatching purpose is mostly found in the western Bengal. In such a case harvesting is done with the whole straw. The erect varieties of paddy like the *Latisail, Kerrsail, Indrasail, Nagrasail* etc. are suitable for this purpose.

k. *Yield*—The average outturn of paddy per acre is 15 mds. in *Aus,* 25 mds. in *Sail,* 30 mds. in *Asra, Aman* and *Boro* but individual growers often get more. This depends mostly on the fertility of the soil, thorough cultivation, care in weeding and a supply of standing water in the field during the growing period.

2. *Wheat*—Wheat is mostly grown in Northern India including the Punjab, Bombay, United Provinces, Central Provinces and Berar. It is not an important crop in Assam or Bengal. It is grown to a certain extent in the drier parts of Malda and Murshidabad districts of Bengal. Under proper cultivation it can be grown in the riparian tracts of Eastern Bengal and Assam as a winter crop for profit.

The best soil for wheat is a clay or sandy loam. Being a *rabi* crop, a dry cold weather is favourable for its growth. Experiments have shown that in Assam proper the application of lime and bonemeal or cowdung favours the growth of wheat. When properly cultivated, an average outturn of about 15 or 20 mds. per acre is expected. As Assam and Bengal mostly consume rice, the cultivation of wheat is seldom practised by the people. Wheat straw can be stacked like paddy to feed the cattle.

3. *Barley*—Barley is grown to a certain extent in some parts of Assam and Bengal as a rabi crop, but it is not considered to be an important crop for cultivation.

Barley will grow well in a loam soil either clay or sand. Application of cowdung or bonemeal favours a successful crop. The outturn on average is about 15 mds. per acre.

Barley is used in making malt extract or beer. Robinson's barley is well-known as a patent food for children and the invalid. Barley straw, like paddy straw can also be stacked as a feed for cattle.

4. *Oats*—Oats (*jai*) are not an important crop in Assam or Bengal. Their cultivation, however, is met with in all parts of India in small patches here and there. This crop can be grown in low-lying riparian tracts as well as in high lands where *aus* paddy grows.

The cultivation of oats is similar to that of barley. The seeds are to be sown in October and November, depending on the suitability of the land. About 20 to 25 seers of seeds are required to sow an acre. In case of high land acidic soils, application of lime is necessary during the preparation of land.

Oats respond well to cowdung which may be applied at the rate of 150 maunds per acre. Oats and peas do very well and are being successfully grown in the government farms at Jorhat, Khanapara and Sylhet for fodder purpose.

Oats are to be harvested in February and March, when the grains are not fully ripe, as otherwise they shed very badly. Oat straw is a good fodder and can be fed both green and dry. The yield of oats varies a great deal according to richness of the soil. The yield in Bengal and Assam comes to about 15 to 20 maunds of grain per acre. Oats have a demand for feeding horses.

Oatmeal is a very nourishing food which is imported from abroad. Although oat flour (*chhatu*) is used by poor people, there is a possibility to grow the crop on a large scale and manufacture the oatmeal which is sold at a very high price in the Indian markets.

5. *Maize*—In Northern India from Behar to the Punjab maize forms the main part of the diet of the poor and is an important cereal crop. Except in the hill districts, it is not grown extensively in Assam and Bengal.

Maize prefers a well-drained gravelly loam soil as is met with in the hills where they thrive best with an application of cowdung. It may be grown in the high land soils in the plains of Assam and Bengal. Maize cannot stand water-logging. It is grown in the *Kharif* season.

Where there is a scarcity of cattle feed, maize may be grown either for silo or green fodder. It is sown from March to June in Assam. Green maize cobs are used as a vegetable and roasted cobs are also relished by children. When properly grown, it gives an average outturn of 10—12 mds. of grain per acre.

6. *Jowar*—Like maize, *Jowar* or the great millet is used as a staple food in some parts of Southern and Northern India. It can also be grown in the well-drained high lands of Assam and Bengal. It is rather hardier than maize and can be grown in a rather poor soil where maize may not grow well. Like maize it cannot stand water-logging.

Jowar can easily be used as a green fodder or as silage for cattle as is usually done in government farms.

Apart from the above two, small millets, namely, *cheena, Marua* and *Kaon* are also grown in Assam and Bengal to a certain extent.

Pulses

The pulses are legumes. When grown in the field, they yield a crop and improve the soil which cannot be done by any other crop plants.

Among the pulses, *arhar,* gram, *matar, khesari, musuri, mati-kalai* and *mung* are commonly grown. They are all *rabi* crops except *arhar* which is sown in the rains in April and May and harvested in March and April next. The pulses are generally grown from October to December and harvested in March and April.

(1) *Arhar or pigeon pea—Arhar* grows well in the high lands of Assam and Bengal. Its cultivation is very limited. It is grown in abundance in Bihar, United Provinces and Central Provinces. *Arhar* grows in all soils except sandy land where it suffers from lack of moisture. It responds well to manuring.

Arhar should be sown in lines at 3 feet each way in April and May with the early showers after proper preparation of the soil. It may be sown in lines with high land paddy or maize at 6—8 feet apart. The crop matures in February and March. The yield of *arhar* varies from 15—20 mds. per acre. *Arhar* weevil and wilt are two serious pests in Assam and parts of Bengal.

Being a legume, it enriches the soil and when grown thickly, it checks the growth of thatch grass. It gives a partial shade to young tea plants and pineapple, when grown in between the rows. Plants, when cut back, will continue to grow for 3 years. *Arhar* plants are used in cultivation of lac in the hills.

(2) *Gram (But)*—The cultivation of gram is limited in Bengal and parts of Assam. It prefers a clay loam soil. It is found to be grown both in high and low-lying inundated areas. A good preparation of the soil is necessary. About 15 seers of seeds are sown in November and December and the crop is harvested in March and April.

(3) *Matar or field peas*—Matar is generally grown in the silted lands in Bengal and parts of Assam. In high lands the soil has to be prepared like that for gram.

Matar grows well in heavier soils where moisture supply is better than that in high land soils. The seed is sown in November and December and the crop is harvested in March and April. It is grown also as a mixed crop with barley and mustard. Its seed rate is about 16 seers and yield about 10 mds. per acre. It is used both as green vegetable and *dal*. The straw is valued as a fodder.

The *Bara-matar* is known as the garden pea and is mostly taken as a green vegetable. It is cultivated in gardens only in rows having bamboo sticks to climb upon.

(4) *Khesari*—The crop is grown in the inundated areas of Bengal and parts of Assam, the latter having a small area under its cultivation. It is sown in paddy lands after the crop is harvested. 15—20 seers of seed are required to sow an acre of land and 10—12 mds. of *khesari* are obtained per acre. The green tops and pods are used as vegetables. It may also be grown in high land loam soils after proper cultivation, but unless there is sufficient moisture, the crop does not grow well. The straw is good for cattle.

(5) *Musuri*—The *musuri* is grown in high and low lands of Bengal and parts of Assam. It thrives both in clay and light soils where there is sufficient moisture. It can be grown in rotation with *aus* paddy. The land for this should be prepared well.

The seed is sown in November and December at the rate of 8—10 seers per acre. It is also mixed with barley and mustard in some places. The crop is harvested in March and April. The yield comes to 4—6 mds. per acre which depends on the richness and moisture content of the soil.

(6) *Matikalai or Mushkalai*—In the inundated areas of Bengal, it is sown as soon as water recedes from higher areas in September—October when the soil is still moist. This gives a luxuriant growth which is necessary both for green fodder and grain. It also grows well in the high lands after proper cultivation when the soil is still moist. Late planting is always detrimental to growth and yield.

Matikalai also grows well in the paddy fields where it is sown in the mud like the *khesari* after the harvest. It takes from 6—8 seers of seed per acre when broadcasted alone. The yield ranges from 4—6 mds. of grain and about 10 mds. of dry straw which is a good fodder for cattle.

Being a legume, *matikalai* enriches the soil very well. It can be grown for grain as well as for green manuring. For the latter purpose it can also be grown in the rains and ploughed under in August or September.

(7) *Mug*—Unlike *Matikalai, mug* is grown in lighter soils both in high and low lands. The soil should be prepared well and the seed sown in December and January. It is harvested in March and April. 6—8 seers of seed will be required to sow an acre of land and yield will be about 3—4 mds. per acre provided there is moisture in the soil. *Sona mug* is highly prized.

Oilseeds

Among the oil seeds of India, mustard, linseed, cocoanut and *til* (sesamum) are important. There are two classes of oils, viz., the drying oils and the non-drying oils. The linseed oil belongs to the former class and the mustard to the latter.

1. *Mustard*—The mustard (both red and white) is generally grown in the low-lying lands as a rabi crop. They grow in a wide range of soils varyings from clay to sandy loam. Application of lime and farmyard manure is very favourable for their growth, especially in the higher levels of Assam where the soil is mostly acid. It requires about 3 seers of seed per acre. The crop is sown from October—November and harvested in February—March. The yield of mustard ranges from 4—6 mds. per acre. Mustard can be sown with other crops such as *Khesari* and *matar*, and gives a yield of about one-half as much.

Mustard oil is mostly used for culinary purpose. For this, the oil is extracted by pressure in *Ghanis* (country mills). About 10 seers of oil can be extracted from a maund of seed. Installation of oil-mills almost in all the towns of Assam and Bengal has facilitated the extraction considerably. The pressed material that comes out of the *ghanis* or mills as a by-product is the oil-cake which is highly prized as a feed for cattle and as a manure.

There is a custom prevalent in some of the hill tracts to sow mustard after clearing the jungle. It grows with the least care and is a good weed killer. In improving the pasture lands, one or two crops of mustard will serve the purpose well.

2. *Linseed*—Both Assam and Bengal grow a considerable quantity of linseed. It grows well after *aus* paddy. The white variety produces oil of better quality than the brown and so preferred. The field should be ploughed when it is still moist and the seeds sown in November—December. It will do better, if sown

early. With an application of cowdung it grows luxuriantly. Linseed, if retted like jute, gives a rough fibre that may be used in making ordinary ropes. The outturn is 6—8 mds. of seed per acre. The oil of linseed is very important in paints and varnishes. It is extracted in the same way as mustard and the pressed cakes are useful as a cattle feed and manure.

3. *Sesamum (til)*—Sesamum is generally sown by the river bank in the inundated areas of Bengal and parts of Assam after jute. There are two distinct types, the white and the black, the former is mostly preferred. They are also sown when the soil is moist in March—April and harvested in June—July. The *rabi Til* is sown in August and harvested in November. The outturn is 4—8 mds. per acre.

The oil is used both for culinary and toilet purposes. The pressed cakes are also used as a cattle feed. *Til* seeds treated in layers with scented flowers for about 15 days give scented oil after extraction which is sold at a very high price.

4. *Groundnut*—It is grown extensively in Bombay, Madras and C.P. mostly in rotation with cotton and *jowar*. In Assam and Bengal, its cultivation is of recent origin and has got a prospect of rapid expansion specially in riparian tracts. The importance of this crop lies not only in its manifold uses but also in its capacity for enriching the soil by fixing nitrogen from atmosphere.

Although the groundnut can be grown throughout the year, it has proved successful only as a kharif crop. The water-requirement of the pods is too high to be met by the dry soils of Assam in winter.

Cultivation—Light loam soil is most suitable for the groundnut. It is very much susceptible to soil acidity which must be neutralised by applying about 10 mds. of slaked lime per acre before dibbling the pods. A heavy basal dressing or organic manure is also essential for a successful crop. The land should be ploughed deep and prepared thoroughly. The shelled nuts of an early variety may be dibbled at a distance of 1 ft. both ways. In case of a late variety which creeps more than an early one, double of the above spacing may accordingly be necessary. The seed rate is about 20 seers of nuts per acre.

The interculture and the weeding require special attention and should be given whenever found necessary. As an ovule is fertilised, the groundnut flower bends its stalk downward and within a few days, the newly formed pod with its sharp pointed end penetrates into the soil where the seed is developed. So a light hoeing at the time of flowering is indispensable for the easy

penetration of the pods into the soil. In case, the flowering stems are seen dancing in air, they may be trampled down when the soil is not too wet. This will help the pods to get inside the soil.

The general yield comes to between 14 and 15 mds. per acre which brings a gross income of about Rs. 70/- or more.

Groundnut has got its manifold uses. When roasted, it becomes a palatable food. It is used in various confectionaries. Its oil is edible and is also used for the adulteration of ghee and the manufacture of artificial ghee, scented oils, candle, soap, etc. The cake obtained as a by-product in the extraction of oil is a valuable cattle feed.

Oil is also obtained from other seeds, such as, cotton seed, sorguja (Guizotia), Perilla ocimoides Manipur *rana* (Amoora), castor (Ricinus), cocoanut, *veranda* (Jatropha) and sun-flower (Helianthus). They are used for various purposes.

Fibres

1. Among the fibre plants, jute and cotton are the two most important crops in Assam and Bengal and are dealt with separately in Chapter XIX and XX. The other fibre crops of minor importance are as follows :—

Rhea or Ramie—It is a perennial shrub, 5-7 feet high with large heart-shaped hairy leaves, having greyish-white colour beneath. It is indigenous in Assam and in N. Bengal and is cultivated in small patches in home-stead gardens.

The plant thrives best in loamy, alluvial or humus soil. The warm moist climate of Assam is quite suitable for its cultivation. It grows well even under partial shade, but can hardly stand water-logging. Rhea responds well to cattle manure and this should be applied year after year.

Rhea is propagated generally from root cuttings, but stem cuttings are also used. Deep ploughing is necessary. The cuttings are planted at about 2×3 feet apart. The best time of planting is April and May when there is plenty of showers. Once planted, the plants will grow from suckers for about 10 years on profitable basis provided proper cultivation and manuring are done.

The stems become mature in 10 months. This is indicated by the withering of lower leaves. Generally, 2-3 cuttings are available. This depends mostly on manuring and moisture content of the soil. The normal yield comes to about 7-8 mds. of dry ribbons.

The fibre is extracted by hand from fresh stems. The stems are first scrapped by a blunt knife to get rid of the soft bark which

are then partially dried. The fibre is later on extracted by hand and cleaned. The difficulty of decorticating by hand is really a handicap in its cultivation, although men, women and children can do this. As there is a demand for it in the market and the price of dry ribbons is about Rs. 45/- to Rs. 50/- per md., it is worthwhile to cultivate this crop on a large scale.

Sunn-hemp—It is an erect annual, 6-10 feet high with bright yellow flowers. It is a leguminous crop which can be used either as a green manure to improve the soil or as a fibre crop for commercial purpose. When young, it may serve as a fodder for cattle.

When grown for fibre, it does well in high-lying light soil. It also thrives in moderately deep and retentive soils. The high lying acid soils are not so favourable for sunn-hemp unless they are limed. Well cultivated garden soil is suitable for its growth. It may be used as a good rotation crop to recoup soil-fertility.

Sunn-hemp is grown both as *Kharif* and *Rabi* crops. The former is sown in April and May and is cut in September or October for fibre or is buried down as green manure. The Rabi sunn-hemp is sown in October and November and is used as a rotation crop with jute and other crops. From the rabi crop seeds are obtained for sale. The latter practice is followed in the Goalpara district which ensures a high yield of jute. About 20-30 seers of seeds are required per acre for sowing broadcast.

For fibre purpose, the crop is harvested when the plants flower. The stalks are then left in the field for a day or two, stripped of leaves, tied in bundles and then steeped in a pool of water. Six to ten days are enough for retting. The bundles are then taken out and the fibre is extracted by hand, washed and dried. The yield of dry fibre comes to about 7-8 maunds per acre. The fibre has a great demand in the market and is sold at Rs. 10/- to Rs. 20/- per maund.

When grown in line in the tea garden, sunn-hemp improves the soil and gives a valuable fibre crop.

Flax—Flax as a fibre crop is not much grown in Bengal. Its cultivation is still under experimental stage, while in Assam, it is worth trial in the drier parts. It is to be sown in October—November when the soil is still moist and harvested in February—March before the rains set in.

Apart from the above, good and valuable fibres may also be extracted from hemp (*Mestapat*), agave, pineapple and Indian mallow.

Sugar

(1) *Sugarcane*—Chapter XVIII is devoted to sugarcane alone.

(2) *Date Sugar palm*—The common date sugar palm that is found to grow in Bengal and parts of Assam is known as wild date (*Phaxenix sylvestris*). This palm is of considerable importance in the Jessore district of Bengal. The *khejur gur* is well known all throughout Bengal. The dates, we so relish, come from Arabia and are not grown in India at all.

The trees are easily propagated from seeds. At the age of 4-5 years, they are tapped for juice. Tapping commences from the latter part of November to the middle of February. The juice is boiled down for gur making. About 8-10 seers of juice are required to make a seer of gur. A tree can give enough juice to make a maund of gur. In Assam it is found to grow scattered in Goalpara, Kamrup and Darrang. Its cultivation for gur making is highly desired in Assam.

It may also be mentioned here that sugar is also obtained to a certain extent from sugar beet and sugar maple trees by tapping as in Europe and America.

Miscellaneous

Pan—It is an article of everyday use in our Indian home for the rich and the poor alike. It is grown mostly by the *Baruis* in *boroj* system in the Surma Valley and in Bengal whereas in the Assam Valley it is grown mostly on areca palm trees and sometimes on bamboo poles. It is an important crop in the hills, specially in the *Wars* (precipitous slopes) of Khasi & Jaintia hills and Haflong where pollarded trees are used for trailing the vines.

Soil—Generally, rich loam to clay loam soils are selected for pan cultivation. The blackish ditch or tank earth which is full of organic matter, is specially suited for this crop. Pan plants cannot stand water-logging and so high land (*vita jami*) above the water level should be chosen. Although both the old and the new alluvial soils will grow pan, yet it thrives best in the latter.

Preparation of the boroj—The site selected for pan should be ploughed or hoed deep and harrowed well so as to pulverise the soil. A trench should be dug all round the boroj as well as a cross trench in the interior about a foot in width and about 2 feet in depth so as to ensure thorough drainage. As the pan vines grow well under partial shade, a frail bamboo lath about 7 feet in height is constructed with live-posts all round having bamboo posts in

the interior over which jute stalks or paddy straw is thinly spread. This gives a partial shade. A fencing of jute stalks is also put up all round. Such a structure not only protects the pan vines from stray cattle but also from high winds and the hot sun both of which are detrimental to pan-growing. Up-right bamboo strips about 6 inches higher than the top are fixed about 10 inches to 12 inches apart in lines and about 18 inches to 24 inches in rows and a pan cutting is planted at the base of each.

Planting—The cuttings are collected from healthy *borojes* of known variety. The *Deshi pan* is mostly grown in Assam while in Western and Northern Bengal *Mitha* and *Sachi* pan are also grown. The cuttings should be about a cubit in length, having half a dozen joints. About 7,000—10,000 cuttings are required to plant a bigha.

The planting time begins in May when rains begin and is continued up to August. As the vines grow, they are tied in the bamboo sticks and allowed to grow straight. When the vines grow up to the top, they are brought down and the stems are coiled and buried under earth *in situ* and the top is tied to the stick and allowed to grow up. This is repeated at least twice during the year.

Manures—Powdered pond-earth, mustard oil-cake and cowdung are generally used as manures for pan. All these materials are dried and then powdered. In manipulating the soil for manuring very often the manure is put in a narrow furrow and the vines remain on a ridge. This furrow drains out the water that might otherwise stagnate in the *boroj*.

Plucking—Plucking of leaves commences in 4 months when planting is done in May or June and about 2 pluckings are available each month except in winter. A bigha of land will yield about 30,000 *pons* (80 leaves making a *pon*) of pan which will fetch a net profit of Rs. 300/- per bigha.

Pan disease—The pan vines in Assam, Bengal and elsewhere suffer a great deal from diseases, caused by Rhizoctonia or Phytophthora, two fungii, which cause the blackening of vines and leaves and have already ruined many *borojes* in the plains, and hills of Assam and Bengal. The remedy lies in rotation and sterilization of the soil by copper sulphate solution and spraying the vines with Bordeaux mixture or kerol.

Blackpepper *or golmarich*—It is a creeping perennial vine, indigenous to Assam. It is found to be grown in homesteads here and there and the vines are trailed on jackfruit, mango and areca palm trees. The berries, obtained from them are used to manufacture

the products known as "Black and White peppers" for which there is a demand in the market. It is found to grow in the hills up to 2,000 feet in Cherrapunji and elsewhere.

The garden loam soil is best suited for its cultivation. It grows well in well-drained rich soil. The plants respond well to cowdung or household refuse and can hardly stand water-logging like the pan.

The blackpepper can be propagated easily from suckers or stem cuttings. Generally, the suckers are uprooted in April and May and are planted near the base of the trees on which they are grown. For large scale cultivation, it is necessary to make a nursery and propagate from cuttings about 18 inches long. When the vines grow, they are tied on the trees. The best way would be to plant a live support, such as, *Palita Mandar* or *Simul* trees, 6 ft. × 8 ft. and plant the suckers near the post of the support. As the trees thrive best under partial shade, the scattered branches of *Mandar* or *Simul* trees serve the purpose very well. The trees are to be lopped partially from time to time. The vines grow from 8-20 feet in height.

They begin to bear in three years after planting and continue for 15-20 years. The blackpepper begins to flower in May and the mature berries are plucked in December when they attain a reddish tinge.

The berries are dried in the sun after boiling and allowed to retain the husk which assumes a black colour. The average outturn from a single vine comes to a seer of dry pepper. The price of blackpepper is about Rs. 20/- per maund.

The *cubeb* or *cobabchini*, which is used as medicine by the *Kavirajes*, is also a creeping vine and grown in the same way. The long-pepper *pipul* is a perennial shrub and can be cultivated from suckers planted at the distance of 4 ft. × 6 ft. It is cultivated in Bengal and its cultivation in Assam is desirable.

Turmeric—It is a annual herb cultivated throughout Assam in small patches mostly for home use. It grows both in plains and hills up to an elevation of 3,000 feet. The crop thrives well under partially shaded situation.

The rich well-drained loam soil is suitable for its cultivation. It does well in high lands, which are above the flood level and respponds to manuring very well. The land should be ploughed deep and thrown into ridges for planting at 9 inches × 18 inches.

The turmeric is propagated by cutting the fresh rhizomes in small portions which are planted on the top of the ridges in March—

April and the crop takes about 9 months to mature. Hoeing is necessary to check weeds. Two varieties are generally grown, namely, the *Deshi* and the *Patnai*. The latter has a better colour and also fetches a better price in the market.

The cost of cultivation comes to Rs. 15/- to Rs. 20/- per acre and the yield about 8-10 mds. of dry rhizomes which give a profit of Rs. 60/- to Rs. 80/-. The rhizomes should be dug out in December--January when the leaves fade and partly dry up. They are prepared for the market by drying in the sun after scalding in hot water. The usual method is to put a little cowdung while scalding. This is believed to ensure a better colour.

The problems of growing turmeric in Assam lies in proper drying of the rhizomes under a dry hot sun which is wanting in Upper Assam and this has caused failures in many cases. Drying in an improvised drier over an oven is desirable.

The ginger (*Ada*) may also be grown in the same way which has also a demand in the market.

GENERAL QUESTIONS:

1. Name the different classes of food crops with examples.
2. Why are the fibres so important? Do we grow jute and cotton in Assam and Bengal? Where?
3. Name the different classes of paddy we grow in Assam and Bengal, stating in particular the season and the water-level of the soil required for their successful growth.
4. How can you get two crops (one *Rabi* and one *Kharif* crop) in your land?
5. What is the usual process followed in a rice-mill and what are the by-products?
6. Name the plants that supply us with oil. Which oil plants are grown in Assam and Bengal? How is the oil extracted?
7. Is there any possibility to manufacture cotton and linseed oils in Assam and Bengal? How?
8. What are the important legumes? Name those which we consume as food. How will you grow them in new and old alluvial soils?
9. Name the plants from which sugar is made.

LABORATORY EXERCISES:

1. Make occasional visits in places where paddy and pulses are grown, making notes on the following:—
   (*a*) Name of varieties grown in the locality.
   (*b*) Methods of cultivation followed.
2. Why is it that broadcast *aus* will not grow unless it is weeded thoroughly? What is the difficulty in weeding in clay soils?
3. Take a trip in winter in the riparian tracts where the cultivators grow mustard, pulses and take notes on varieties and the methods of cultivation followed.

CHAPTER XV

FRUITS

To grow fruits either for profit or for pleasure requires patience, labour and intellect. Every cultivator should have in his farm holding a few fruit trees to supply the demand of his own family. To start a garden of mango, litchi, guava, pineapple, plum, cocoanut or oranges in the plains, and oranges, apples, pears, peaches or plums in the hills will certainly be profitable provided the man knows how to deal them. Merely growing a few orange or mango trees with other fruit trees in a haphazard way on foothills or plains in a semi-wild condition does not at all conform to the requirements of a 20th century fruit garden. A large number of fruits are grown in Assam and Bengal of which a few important ones are dealt with below.

The Mango

Mango is the king of fruits in India. It is found to grow luxuriantly in almost any locality in India where there is moisture in the soil, but its success seems to be attained in a deep well-drained soil under a hot moist climate, having a moderately dry flowering period especially in February and March. Mango trees are also found to grow in cold regions where they are not badly affected by frost. It has a strong root development and is a hardy plant that can stand water-logging for a long period. Owing to the prevalence of mango weevil, which finds a favourite breeding ground in highly humid climate, the growing of mangoes is not very profitable in the Eastern Bengal and Assam. In the Western Bengal the mangoes of Maldah and Murshidabad are well-known. It is in these two localities in Bengal that mangoes are free from weevils and are grown commercially. The best mangoes in the Calcutta market come from Malda, Bihar, Madras, Bombay and C. P.

Propagation—In the Eastern Bengal and Assam mangoes are generally grown from seeds and the result is that there is no distinct variety and consequently the fruits are very poor in quality. In a mango-growing district like Malda, Murshidabad or Bihar no one can think of planting seedling trees for a profitable garden. Only inarched and sometimes air-layered trees of good

known varieties are planted. These bear fruits like the parent plants, while a seedling tree is liable to vary considerably.

Planting—Mango trees should be planted at 30—40 inches apart in a systematic way and only inarched or air-layered trees should be used. They may be planted well in a square system and until the trees come to bearing, inter-cropping with vegetables or root crops, such as turmeric and ginger, may be adopted. This will kill the weeds, keep the garden under proper cultivation and give a marginal profit to the grower.

In order to plant the trees, a hole should be dug about two cubits in depth and the same in width. This hole should be covered with well-rotten farmyard manure, lime and leaf-mould at least a month before planting the nursery trees, which should be planted during the dormant season in winter, especially before the rains begin, and watered as need be. Only balled nursery trees should be planted.

Pruning—The trees require pruning just after the fruit is harvested. Such a treatment gives a good shape to them and checks unnecessary wood-growth. Generally, inarched or layered trees form themselves into a good shape. An ideal mango tree should form a semi-circular shape on top and should not be more than 20 feet in height. Tall trees, as are met with here and there, can hardly be handled properly. All irregular and weak branches should be removed. As too much wood-growth reduces the regular annual bearing, the trees, may judiciously be pruned at every alternate year. After the fruits are harvested, one should go round the trees in the orchard and prune them as need be. When the branches become bushy and the leaves are smaller, the tree should be pruned. A good deal depends on the judgement of the pruner.

Manuring—As a regular satisfactory crop is desired each season, one should manure the trees every year. Application of farmyard manure, bonemeal or sodium nitrate with a small quantity of sulphate of potash in the form of a ring about 3 feet away from the base of the young trees is very helpful. When applied in this way, heavily pruned sickly or old trees give a flush of growth. In no case any manure should be applied at the base right close to the trunk of the trees. In a regular garden farmyard manure and fertilisers may be applied by ploughing them under about three feet away from the trunk of the trees. In a growing garden, green manuring with legumes is very useful in supplying enough humus to the soil. Clean culture by ploughing, harrowing

and cultivating the field is always helpful in controlling the insect pests and weeds and in conserving the soil moisture.

Picking fruits—Mangoes should be picked carefully from the trees by hand and put in a canvas bag so that they do not get injured. Rough handling always causes a considerable callousness inside the fruits and rottage in storage. In case of higher trees a step-ladder may be used. It is not wise to climb up the small trees, as one is liable to damage the branches. Where the fruits are too high to reach by a ladder, one should use a bamboo-pole picker (*chorkota*) or a picking pole with a net-bag. Fruits should not be allowed to fall on the ground, but should be put gently in a basket or a box to carry them home. Always remember that any wound or bruise will cause a fungus growth to spoil the fruit in a few days.

Packing fruits—At present bamboo baskets are used to pack the fruits with mango leaves or straw. If properly picked and packed rather tight, the fruits will keep better. Where possible, packing boxes of 12 inch × 12 inch × 24 inch size, having a capacity of 3,456 cubic inches (inside measurement) may preferably be used for distant markets. In such a case the individual fruits should be wrapped in thin tissue paper and packed in 4 or 5 tiers deep according to size. For this the fruits should be graded before they are packed. Considering the prices of good fruits in big markets, packing in wooden boxes will be of great advantage in fetching a better price provided it is introduced by intelligent dealers to develop the export trade both at home and abroad.

Marketing fruits—Owing to the lack of regular transportation facilities, the marketing of fruits in India is really a great problem. Although hundreds of baskets are sent by railway wagons in various parts of the country, a good many are sent by river steamers, country boats and country carts. Fruits are very often damaged on the way to market due to rough handling or are pilfered in Railway or Steamer transit for which no remedy has yet been tried. On the other hand, the boat traffic by the big rivers of Bengal is not very safe, especially during the rainy season. It is really a pity that those, who supply fruits in our big markets as middlemen are mostly ignorant people, who seldom understand the value of careful and systematic transportation and consequently lose a good deal. Without dissemination of proper knowledge among the growers and the middlemen about picking, packing and marketing the fresh fruits, the industry can hardly thrive. Mango growers' associations are urgently required to make mango growing and marketing a profitable industry.

Mango weevil—The most inveterate foe in growing a successful crop of mango in the Eastern Bengal and Assam is the mango weevil. It is for this pest that the mangoes in this area are not profitable.

Life history—The weevils generally live in the soil and in the crevices of bark. At the time of flowering or when the fruits are set, they come out in numbers and either crawl up the trees or fly to the inflorescence or fruits. When the fruits attain the size of a marble, they begin to lay eggs in them. The incisions made for laying the eggs are healed up quickly and the eggs remain inside the fruits and ultimately hatch to larvae. These larvae feed on the pulp and burrow holes inside the fruits. By the time the fruits mature, they pupate and ultimately come out as adult weevils. They hibernate in winter in the crevices of the bark of trees and in the soil. Their attack is less observed in a tree whose base is washed by annual flood water. It is also noticed that trees growing on the bank of tanks or rivers are not so much attacked.

Remedy—As the weevils hibernate in the crevices of the bark and in the soil, regular ploughing and cultivation with occasional irrigation of the trees in winter, and judicious pruning and cleaning of the trunks after the fruit is harvested will control them to a large extent.

The Orange

The Khasi Hills may be called the native home of oranges in India. Other centres of oranges are met with at Nagpur, Poona, Nilgiri hills and Delhi. Very sweet oranges are also grown in the foothills of Darjeeling and Nepal. The best oranges of commerce that are found in Bengal markets, commonly known as Sylhet or Chhatak orange, come from the foot hill regions of Cherrapunji in Khasi Hills. (Fig. 44).

The oranges in the Khasi Hills are grown in a semi-wild state. The trees are propagated directly from seeds and they are planted with mango, jack, guava, *tezpat* and areca palm trees. The fruits are carried down in baskets (*Thapas*) to Thariaghat and other places and thence by boat to Chhatak whence they are transported mostly by country boats and to a certain extent by steamer and railway (via. Sylhet) to Calcutta and other places. No systematic picking, packing and marketing are adopted by the people, but these are urgently required to bring the orange industry to a commercial success.

Oranges should be propagated by budding from scions of well-known trees. For this, the seedlings of sour orange (*Karun jamir*) and shaddock (*Jambura*) may be used as stocks. In planting the trees, it is better to plant them at 15—18 feet apart. This will give enough space for interculture. Growing of intercrops, such as vegetables, pineapple, turmeric and ginger until the trees bear fruits, is advantageous.

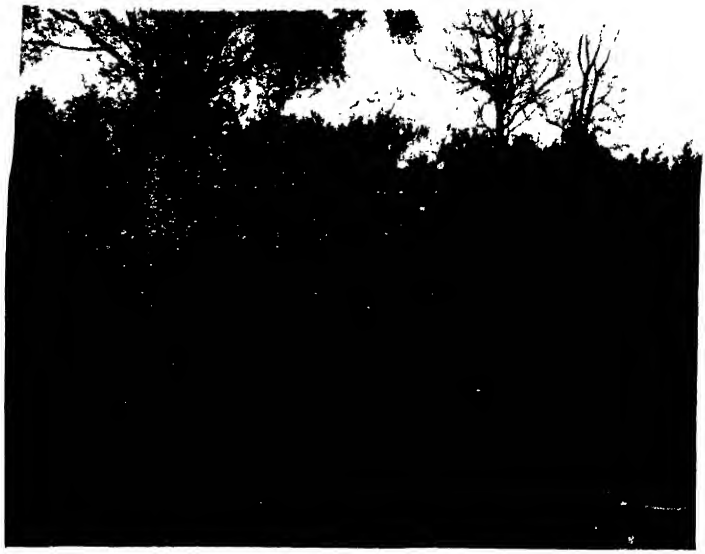

Fig. 44. Orange garden in foot-hills (Khasi Hills).

As the trees are not pruned, they usually grow tall with a few branches, and as a result the branches do not spread all round and the fruit area is very much limited. Systematic pruning is required to change the trees into a semi-circular or vase-shaped form, which is mostly desired for orange trees.

Nursery trees, whether seedlings or budded plants, should be cut at the top with 3 or 4 branches left in each while planted. In the second season the trees should again be pruned. A similar 3rd year pruning will give the desired shape. In the case of a budded nursery stock, it will bear in the 3rd year, whereas seedlings do not come to bearing until they are 7—8 years old.

Soils—Naturally oranges thrive well in a calcareous rocky soil in the Khasi Hills where the trees are known to live even for 100 years. In the plains the high well-drained loam soils are the most suitable for them, where the acidity is not very high. Moreover,

they are found to grow only in a few limited areas in the plains, especially by the river banks, where the silt deposit by occasional floods changes the texture of the soil and increases the fertility. A land, having a sandy top soil and a clay sub-soil, will grow orange provided humus is added properly. Growing orange in a defective soil has resulted in a failure in many parts of Assam. A foot-hill with a gravelly sub-soil is dangerous, as it allows the moisture to run out quickly from the sub-soil.

Irrigation and drainage—The climate of Bengal and Assam is rather too dry in winter and too wet in summer. As the water requirement of evergreen trees is greater than the deciduous trees, it is required to water them in dry season to keep up their natural growth. In the calcareous slopes of the Khasi Hills, water percolates down from the higher regions all the year round and as the orange enjoys a calcareous bed, the trees grow there luxuriantly under the influence of favourable natural conditions. In the plains, if ever an attempt is made to improve the industry, efforts should be made to supply a similar condition by liming the soil and irrigating the trees in winter. Orange trees seldom stand the water-logged condition of the soil in the rainy season. In the plains, where necessary, narrow ditches should be cut to afford a chance of good drainage as is done in tea gardens.

Picking and packing—The fruits should be carefully picked by hand when mature. They may preferably be cut with a clipper so that the stem end may be left on the fruit. This will check evaporation and the fruit will keep for a longer time.

The rough way in which fruits are handled in the Khasi Hills causes them to get bruises and wounds on the rind and as a result, a large number of them is attacked by fungus diseases. When carried down to the markets of Bengal by boat, hundreds of these spoiled fruits are thrown into the river. This unnecessary waste can easily be checked by careful handling of fruits. In the Surma valley fruits are packed in bamboo baskets with a gunny-sack cover, while in the Assam valley round bamboo baskets with a cover of the same material are used to advantage. As pinewood is a suitable material for packing boxes, they may preferably be packed in boxes 12 feet $\times$ 12 feet $\times$ 24 feet, each being wrapped in tissue paper which will fetch a good price, as properly packed oranges are sold at high price in the Calcutta market. (Fig 45).

The most pressing demand for improving the orange industry in the Khasi Hills and Darjeeling lies in the establishment of bona-fide organisations under the name of Orange-growers' Associations

to handle properly the problems of picking, packing, transportation and marketing of the commodity.

Insect pests—The orange trees suffer a good deal from the attack of borers. At the first stage of their growth, they bore through the bark of the trees, then the trunk and ultimately kill them. The young trees suffer much from the lemon caterpillars and the twig borers. Unless one takes care to control them, it is not possible to make any satisfactory profit. In order to check the borers the base of the tree trunk should be white-washed every year and a band of cotton or rag put at about 3 feet from the ground. The trees are also badly infested by mealy bugs and other scale insects. They should be controlled by spraying the trees with kerosene emulsion. In fact, clean cultivation is always necessary to control the insect pests and induce a thrifty growth of the trees.

Fig. 45. Packing orange in boxes and baskets.

Yellowing disease—The most inveterate enemy of orange trees in Assam is the yellowing of leaves. This is different from "die-back" which causes the tops of branches to die, while the leaves of the tree in other parts remain green at first. It is very often found that the leaves of bearing trees begin to turn yellow and die from the top until within three or four years nothing is left but the fuel wood

This occurs even in young trees. Once a tree is affected, it seldom recovers. The disease is found not only in other parts of India but in all citrus-growing regions of the world. No definite remedy has yet been found out. As the prevalence of the disease is found mostly in the plains, it is therefore ascribed to water-logging especially in the rainy climate of Assam. Consequently, it is advisible to plant the trees on a slope or allow sufficient drainage by narrow deep drains between the rows. As orange trees cannot stand acidity of the soil, application of sufficient quantity of lime is always useful to get satisfactory growth. Furthermore, deficiency of phosphates in the soil many cause the yellowing of leaves in orange trees, of which nothing is known definitely.

The Banana

The banana is one of the common delicious fruits in India. There are some well-known varieties—the *Martaban, Sabari, Agniswar, Amartasagar* and *Jahaji*—which always have a great demand in the market. They can be grown successfully with a little care. The ordinary plantains grow almost anywhere of which some are only fit to be used as a vegetable.

Banana grows well on a loamy soil which is well-drained. They are grown from suckers, which are generally transplanted in March and April just at the time when the rains set in. Once planted, a banana clump will grow well for 3 years, but the 3rd year's crop is always a poor one. The method of banana cultivation of Rampal, Munshiganj (Dacca) is well-known. There the people select a high land for banana cultivation on which they raise new earth from a ditch in winter and plant the suckers in spring in a regular square or rectangular system. The suckers are planted about 8 cubits apart and interculture of termeric, ginger, brinjals etc. is common. The crop is obtained for three or four years and then the land is raised by new earth again which is ploughed well and new suckers are planted. This method has improved the banana to its perfection at Rampal. The cultivators there know the utility of ash, which is liberally supplied in the garden. It is a common practice to cut back the suckers once or twice during the rainy season. This makes the suckers strong and fruit well. Clean culture is the secret of success in banana cultivation.

Insect pests—Occasionally borers make holes through the sheath of banana plants which, in a neglected garden, becomes so serious as to cause them break down in the middle. The old

clumps are also infested by earth-worms in a similar way. Moreover, there is a praticular red bectle that feeds on the inflorescence which disfigures the fruit very badly.

Remedy—For borers and earth-worms a clean culture is absolutely necessary. Moreover, when 3 or 4 years old, a banana clump should be entirely removed, and a new sucker planted after a thorough ploughing and cultivation. Raising of the silted earth from a ditch will help a vigorous growth of the clumps.

Marketing—There is always a good market for bananas in Calcutta. The whole bunches may be packed in crates or bamboo baskets which will stand long transhipment well from Eastern Bengal or Assam. For this the bunches should be cut when the fruits are well-matured but not ripe. Facilities for transportation and marketing of this fruit are highly welcome.

The Litchi

Litchis are mostly grown from air-layers. When planted properly, these layers grow naturally into a vase-shaped form without much care. They grow well in a loamy well-drained soil and in four or five years become profitable. The Mazaffarpur litchis are well known. They are well-suited to the soil and climate of Assam and Bengal. The litchi trees should be planted at 25—30 feet apart.

Litchi trees suffer badly from leaf-curl. It is caused by a mite which is a persistent pest. The remedy is to prune the trees removing all the leaves and spray with a crude oil or kerosene emulsion. This is done better after the fruit is harvested.

Bats and crows are a constant pest to the mature crop. For this, they should be covered by old fishing nets, if possible. Making unusual noise by split bamboo poles is also helpful.

Litchis are picked in whole clusters and packed in baskets, interlaid with litchi leaves. Strong baskets should be made for long distance journey by railroad or steamer. Packing in barrels with saw dust may also be resorted to for distant markets, as is done with grapes.

The Guava

Guavas are found to grow in any part of India. The best varieties come from Behar and United Provinces. They are grown mostly by air-layer and sometimes by inarching. They naturally do well in the high lands of Assam and Bengal.

Like litches, guavas will generally make good trees without much care. They will do well in any soil ranging from light loam to clay

The guava trees should be planted about 20 feet apart. They sometimes suffer from Pythium (fungus disease) on the stem. Weak and sun-burnt branches should be removed. Bearing trees should be pruned every alternate year.

Guavas should be packed in baskets, interlaid with guava leaves or straw. Ripe fruits are very easily bruised and rot. They should be handled carefully.

The Pineapple

The pineapple is a delicious fruit, which can be grown almost anywhere in the high lands of Assam and Bengal. The pineapple of Jaldhup in Sylhet has a sweet flavour of its own. The exotic varieties, such as the Smooth Cayenne, Kew, Spanish and Queen are also found in the market. The Smooth Cayenne and Queen have established themselves in many parts of Assam and Bengal. When properly cultivated, they do well and fetch a good price (Fig. 47).

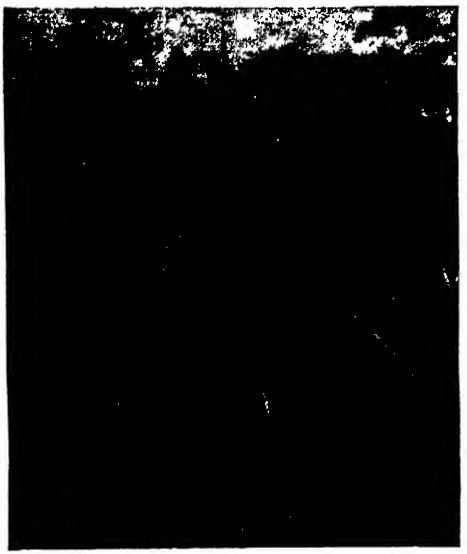

Fig. 46. Pine-apple garden, Jorhat farm.

Pineapple can be grown for profit in the *tilas* of Assam and Bengal, the soil of which is especially adopted for the purpose. They need very little care. They are propagated from suckers, but the crown and robbers can also produce plants, although they fruit rather very late. The pineapple gardens at Srimangal, Jaldhup,

Moulvibazar, Akhaura and those at Tezpur in Assam valley are well known.

The pineapple may be planted 4 feet apart, the interspace between the rows being cultivated regularly to kill the weeds. A liberal application of manure is necessary to get a satisfactory growth of the plants.

Pineapple does well under partial shade. For this reason the planting of gold-mohor, cassia, bogamedeloa and arhar, as is grown in the tea gardens, is very useful. In no case thatch grass should be allowed to grow in a pineapple field for which bogamedeloa or arhar may be grown in the interspace between the rows as a control.

Crows, jackals and wild boars are a serious pest to mature pineapples. In order to scare away the crows, white twine thread may be hung crosswise over the field.

Packing pineapple for distant markets is an important problem. Only mature but not ripe fruits, having 2 inches of the butt-end and the crown, are required for the purpose. The fruits may be packed in strong bamboo baskets, but they should be packed tightly in boxes or crates with straw. Well-packed pineapples will reach any market in India in good condition.

The Jackfruit

Perhaps no fruit in India or elsewhere attains such a big size as the Jackfruit. It is generally grown in plenty both in the hills as well as in the high plains of Assam and Bengal, where the climate and soil are especially suited for their growth.

Jackfruits are generally propagated from seeds. The trees attain a considerable size like the mangoes. When pruned, they attain a good rounded semi-circular shape. They should be pruned to induce a vigorous growth, when the tree becomes old and the twigs thinner with scanty smaller leaves. They improve by pruning. There are two varieties—the soft and the tough. The former have a demand in the market. The green fruits are highly prized as a vegetable. The trees cannot stand water-logging for a long time and so should be planted on higher levels.

The borers cause a considerable damage to the trees. Liming the base, tying a straw band and a clean culture seem to be the only means to control them.

The Cocoanut

The sea coast of India is the natural habitat of the cocoanuts where the saline soil and climate are quite favourable for their

growth. They may be grown far away in the interior provided care is taken to supply a similar soil condition. They do well by the bank of tanks and ditches. Cocoanut cultivation is very important in Southern India, especially the Travancore State where the cocoanut oil and the coir industry are very important. The oil is obtained from the halved dried nuts, known as "Copra", and coir from the fibrous husk of the fruit.

Before planting the seedling, a hole should be dug in the soil about 3 × 3 feet. The hole should be filled up partly by a mixture of soil, manure, lime and common salt in the proportion of 75 : 10 : 10 : 5 respectively. The seedling is to be put in the middle and the rest of the hole covered with soil. The seedlings are very often attacked by white ants. Dipping the germinated seed, in crude oil or kerosene before planting and watering the plants with a mixture of same will control them.

There are two serious insect pests to cocoanut trees. The first is the rhinoceros beetle and the second the palm weevil. To control them, the head should be cleaned twice a year and the base of the tree white-washed every year about 3 feet from the ground with a straw band to check the crawling of the beetle.

The Papaya

The papaya is a delicious fruit and is highly prized for its medicinal properties. It cannot be grown on hill stations where the elevation is more than 3500 ft. It is generally grown in well-drained rich soils and cannot stand water-logging.

The papaya is grown from seeds. The seedlings are ready for transplanting in the field when they are about a foot high. They may be planted at 10 feet apart. There is no definite flowering season for this fruit. There are three kinds of plants, viz., the male, bearing the staminate flowers in pendant racemes and the female, bearing the pistillate flowers and the hermaphrodites, bearing the stamens and the pistils. One male should be left for every 20-25 females so as to get perfect fruits.

The papaya trees generally bear fruits in 8 to 10 months' time and fruits are formed continuously. Generally the trees bear a good crop for 3 years and then the size of the fruits gets smaller. The fruits need thinning, otherwise they cannot grow in full size. The top of the young plant may be cut to allow branching. There is a great demand for this fruit in the market. Well-matured but not ripe fruits can easily be packed in boxes or baskets for distant markets.

Apart from the evergreen fruit trees, mentioned above, a number of deciduous fruits are grown in the cooler climates of hill stations such as Shillong, Darjeeling and other places. They are apple, pear, peach, and plum. In India, deciduous fruits are mostly produced in Beluchistan, Kashmere and the Punjab for commercial purpose.

The Apple

The apple is found to grow extensively in the Punjab, Kashmere and Beluchistan, where there are regular orchards. The Kulu and Kashmere apples are well-known in Calcutta and Delhi.

The apple will grow almost in any soil except the sandy and clayey soils in the higher altitudes of Shillong and Darjeeling. When properly planted, it thrives best in a deep, rich, moist calcareous and well-drained soil. It never flourishes in the plains of India.

Apple is propagated by root grafting on the roots of apple seedlings. A larger number of trees are propagated in this way at the Government Fruit Garden, Shillong every year. The trees may be put 15-20 feet apart. The best time of planting is December and January when the trees are dormant. Apple trees require proper pruning, manuring and hoeing, without which the trees will not thrive well.

The most dangerous insect pest of apple is the woolly aphis, the so-called "American blight". It attacks the trees from the roots to the tip of the stems. There is a seasonal migration of the insects from the roots to the stem and vice versa under favourable conditions which is not so well-marked in Assam. They are very difficult to control. Attempts should be made to control them by two thorough consecutive sprays with a mixture of kerosene emulsion and nicotine sulphate both in winter and summer.

The Pear

The common pear, the *Nashpati,* found to grow in the Khasi hills, is not considered to be an edible fruit. It is so gritty and fibrous that one can hardly swallow its pulp. It is sub-acid in taste and juicy.

The sweet delicious pears, found in the markets of Calcutta are of European origin. They are found to grow in the hill stations of India and especially in Kulu (Punjab).

Like apple, pear will grow in the hills provided they are properly cultivated. In the high plains of Assam and Bengal, the

common Nashpati may be grown but it is never profitable, while the European pear seldom stands the moist hot climate of the plains.

Pear may preferably be propagated by budding or grafting on its own roots. In the hills the local variety is grown from cuttings only. It is profitable to have one pear tree of good quality than half a dozen of the country variety found in every homestead in Shillong. The trees may be put 15-20 feet apart like the apple and the time of planting is the same.

The Plum

The European plums have already found a foot-hold in the homesteads of the Khasi people. The trees that are found here and there are thrifty and profitable. They are grown in other hill stations as well as in the Punjab and other places in N. W. India.

Plums are generally propagated by budding on ordinary local plum stocks. They may also be propagated by sprouts. They grow well on well-drained loam-soil and may grow in the plains with care.

Plums grow very rapidly. They should be pruned well, which induces a better growth. Long branches in the beginning are always detrimental. The trees should be planted 10-12 feet apart in December and January and in case there is not sufficient moisture in the soil, the trees should be watered.

The Peach

The ordinary peach is found to grow both in the hills and the plains, while the European varieties grow only in the former. Like the Nashpati, the local peach has not much value. It may be used as a good stock for scions of the European peach. It thrives best in a well-drained sandy laom. It is a thrifty grower and will do well with a little care.

The European peach is generally propagated by grafting. Plants, grafted on the local stock, grow well even in the plains. They may also be propagated by budding. Reciprocal grafting of peach on plum or plum on peach is always successful.

The trees should be put 15-20 feet apart in winter before the rains set in and should be properly pruned and manured. It may also be mentioned here that both the peach and the plums have a commercial prospect in Shillong and the fruits will get a ready market in Calcutta provided they are packed well for the purpose.

QUESTIONS :

1. Name some of the evergreen and deciduous fruits that may be profitably grown in the hills and the plains of Assam and Bengal.
2. What are the effects of producing trees by budding and grafting? By seeds?
3. Why is it that there is no particular recognised variety of mango or orange in the Eastern Bengal and Assam?
4. What do you mean by a nursery stock? How will you grow it in your garden?
5. How would you proceed to start a fruit garden?
6. Why is pruning useful to a fruit tree?
7. What do you mean by yellowing of orange trees and how can you control it?
8. Why should you pick your fruits carefully and pack them well for market?
9. *How do the oranges travel from the Khasi hills and Darjeeling to the markets of Calcutta?*
10. *How can you help the orange growers of the Khasi hills by a co-operative organization?*

LABORATORY EXERCISES :

1. Get the stems of mango, litchi, guava, pomegranate, apple, orange and sapota and note how the fruits are formed in them.
   a. What is a fruit? Do apple, jack fruit and mango come out in a similar way?
   b. What part of the flower of apple, pineapple, mango, papaya, fig, and jack fruit develops into a fruit?
2. If possible, make boxes of 12"×12"×24" with used kerosene tin boxes and pack oranges or mangoes in layers diagonally such as 4 and 3 or 5 and 4 each in alternate rows until the layer is finished. Four or five such successive layers will fill up the box. Wrap the fruits with tissue paper before they are put in. The pack must be tight with a cover on top. Count the number of orange or mango and find out the net weight of the box.
   a. Will fruits keep better, if packed in this way for long translhipment? If so, why?
   b. Make an estimate of cost and profit in such a packing for Calcutta market.
3. Prune a few orange trees, if possible, in a garden.
   a. During planting in the field.
   b. 1st year after planting in the field.
   c. 2nd year after planting in the field.
   d. 3rd year after planting in the field.

   Note the results after a season's growth.
4. Make a plan and estimate of a 10—acre orange or mango garden including the value of land in consultation with your teacher.
   a. How many nursery trees do you need per acre (when planted a 15 feet apart) (see Appendix IX).

CHAPTER XVI

VEGETABLES

Vegetables can be grown throughout the year either for market or for home use in small areas on a higher level in and around the homestead. The system of rotation of *aus* or *jute* with winter vegetables is successful in many localities. The dearth of vegetables is keenly felt both in Assam and Bengal especially in the former. In a small holding an intensive cultivation of vegetables gives a satisfactory profit. This is commonly called "Market Gardening" or "Truck Farming." For a middle class man, there are both pleasure and profit in growing a patch of vegetables, while for a poor man it is the main stay for his livelihood. When grown in the garden, it always means more food and less expenditure for the family.

The Potato

The potato may rightly be called the king of vegetables and can be grown both in the garden and in the field. It is grown commercially in the Khasi Hills, Nainital and Darjeeling which supply the Assam and the Bengal markets. In the plains potatoes grow very well on jute or aus paddy land and paddy seed beds with an application of farmyard manure and ash. To grow a successful crop of potato, the soil should be ploughed deep and a thorough clean cultivation is needed. Potatoes grow well in a loam or sandy loam soil. Every year improved varieties of potatoes are distributed by the Departments of Agriculture both in Assam and Bengal to the cultivators in the plains. The problem of growing improved varieties of potatoes in the plains lies in the proper storage of seed potatoes and supply of water by irrigation.

In the Khasi Hills potatoes are grown in the "Jhum system" of cultivation. For this purpose the land is first cleared and then the jungle is burnt down to ashes in *situ*. The soil is then prepared with a *kodali* and the seeds are planted in rows. This is continued for three years when the land is left fallow for several years. This is a ruinous practice. It should be discouraged and replaced by the "Terrace system" of cultivation, as is found in the Naga hills.

The seeds (tubers) should be obtained from reliable seed dealers. They should be kept in a dry place and selected by hand before

planting. After the soil is ready, potato seeds should be planted in rows in the furrows, made by a plough or a hoe. It is a winter crop in the plains, while two crops are grown in the hills. Under the plain condition it should be watered once a fortnight. When the plants grow about 6 inches high, they should be earthed by a hoe and two such earthings are necessary. No weeds should be allowed to grow and the soil should be kept loose.

Generally very small sized potatoes are kept for seed. Medium sized potatoes of which 30 or 32 make a seer do very well in planting. If potatoes are large, they may be cut in halves and treated with Bordeaux mixture or ash before planting. The seeds should be planted about a foot apart, having an interspace of about two feet between the rows.

The best time for planting potatoes in the plains is October, when the rain ceases. In the Khasi hills two crops are grown, one from March to July (Summer) and the other from August to February (Winter). The summer crop is the main source of potato supply. The winter crop is used mostly for the seed purpose. This is rather a poor practice. If the summer potatoes could be stored well and planted in the next season, it would have given a better outturn. This has already been found to be true by experiments at the Government farm, Upper Shillong. The potatoes for seeds should be selected by hand. Propagation from unselected small seeds has caused the best introduced exotic varieties to degenerate after a few years.

Manure—Potatoes do not grow well in a poor soil. For this reason abundant farmyard manure at the rate of 200—300 mds. per acre should be applied at the time of ploughing. As the cost of manuring is very high owing to the dearth of cattle manure, the application of leaf-mould and ash is quite practicable and useful.

Irrigation—In the plains, potatoes require irrigation, while in the hills they grow without it. Irrigation is mainly done by basket or *don*. In the Sylhet district potatoes are grown extensively at Bejura and Satgaon, where water is carried in the field through small irrigation ditches, which sometimes extend about one-half mile in length from the source of supply. Here the cultivators work on a co-operative system and that is why they are successful in growing the crop. Potatoes are also extensively grown in the Rangpur district of Bengal in a similar way. After each irrigation it is better to loosen the earth with a hoe. A Planet junior hoe will serve the purpose very well.

Storage—The problem of storage is very important in the plains. The indigenous potatoes can be stored well in dry sand which is a common practice among the cultivators. Potatoes can also be stored in dry saw dust and ash. It is for lack of suitable storage-facility that the recommended improved varieties cannot be stored in the plains and so fresh seeds are transported every year for supply in the plains both by Government Seed Depots or private dealers. Potatoes may well be stored in the plains, if a reinforced concrete cold-storage house is made for the purpose in suitable centres. As for the hills, godown cellars will serve the purpose very well. The success in storage depends on temperature, humidity, exclusion of light, thickness of the pile and quality of the potatoes stored.

Treatment—Before the potatoes are stored or packed for shipment, they may be washed in a vat, containing Bordeaux mixture, 1% Formalin or .1% Mercuric chloride and dried well before packing. Such a treatment will make the potatoes stand the transit and keep better in storage. The last should be used for seed potatoes only. The present method of packing potatoes in gunny sacks is very defective. They may be packed in returnable barrels, which will ensure them against rotage for days after they reach their destination.

Insect pests and fungus diseases—Red ants and cut worms are two enemies of potatoes. The incidence of red ants on potatoes is almost a characteristic of red and old alluvial soils and hence such soils should be avoided for potato cultivation. However, if the field is irrigated by flood system once in a fortnight, both of these pests can be checked satisfactorily. In the case of furrow irrigation, a little crude oil may be mixed with the water which will drive them out of the field. The wild boars are very troublesome in many localities. For this, the villagers ought to have a co-operative fencing to save their crop.

The potato blight or the Phytophthora is the most serious disease of potatoes. To save the potato crop one should spray the potatoes with Bordeaux or Burgundy mixture when they are about 6 inches high. A similar spray about two weeks later will ensure the crop against Phytophthora (Fig. 47). Moreover, potatoes should be selected by hand before they are planted. This operation will remove the diseased tubers.

The Radish

The radish can be grown preferably in the higher levels around the homestead. It grows in almost any kind of soil

provided it is not water-logged. A little lime and manure will give a good crop. The well-known "Bombai Mula" gives a better profit than the Deshi varieties. The land should be prepared well as for potatoes. Deeper ploughing or hoeing is always necessary for a good crop. The seeds should be sown in rows. The seedlings germinate in 3 or 4 days. When they are about six inches in height, they require thining and may be sold as pot herbs,

Fig. 47. Spraying potatoes for phytophthora.

Sak. If the weather is dry, the application of water every alternate day is very favourable to give a flush of growth to the young plants. It is a general practice among the cultivators to expose the roots partly which makes them more thicker and longer than those which are under-ground. Radishes are not very much attacked by insects, except webby caterpillars, which can be picked up by hand.

The Brinjal

Brinjals do well in a sandy loam soil. When paddy seed beds are dry in October and prepared well, they can be grown very early. Application of manure always gives the best results. There are many varieties grown in Assam and Bengal, of which the Mymensingh round and the Kamrup long (Muktakeshi) varieties are best.

The seeds are to be sown in a seed bed, which should be manured well. A cool shady place suits them best. They may even be grown in December and January in paddy fields. The seed bed should be watered every alternate day, if there be no rain. The seedlings should be transplanted about 3 feet apart in the field. During the drought, irrigation water will give a flush of growth to the plants.

Brinjals are attacked badly by a stem borer, which is a constant pest to young shoots. It is a larva of a moth. The affected shoots should be removed. The application of kitchen ash on the affected branches controls the borers to a large extent. Arsenical spray in a commercial garden is urgently required to save both plants and fruits from the attack of borers.

The chillies and tomatoes belong to the same family and they may be grown in the same way.

The Cabbage

Cabbages, cauliflowers, turnips, kohl-rabi etc. are known as English vegetables. They can be grown in a garden with a little more care than radish or brinjal. They have a good market in every place (Fig. 48).

Fig. 48. A back yard cabbage patch, Nowgong.

Cabbages will do well in a loam soil, which should be ploughed deep and manured heavily. They are the cold weather vegetables in the plains, but can be grown almost all the year round in hill stations. They are a very good paying crop next a

town. It is only for the last two decades that such truck farming has developed near large towns in Bengal and is increasing in Assam.

The seeds should be sown in a seed bed or preferably in seed boxes, which should be manured well. It is better to cover the bed until the seeds germinate. They should be exposed to partial sun-shine and should be protected from heavy rains. So it is better to cover them at night fall when a heavy rain is expected. Making seed beds under permanent open sheds is also helpful. When the seedlings are 3-4 inches in height showing 4 leaves, they are to be transplanted in rows. Good results are obtained by transplanting the seedling twice, i.e., once when the seedings are 2 inches in height and again when they grow about 4 inches. The first transplanting should be done in a corner of the field in well-prepared beds. For planting in the field a small depression covered with well-rotted farmyard manure is to be made ahead at two to three feet apart (for cabbages and cauliflowers only), which mainly depends on the size of the varieties grown, and the seedlings should be planted, carefully watered and shaded from the hot sun by banana sheath. Turnips and kohl-rabi can be put at 1 foot apart. As the plants grow higher, this depression is to be gradually filled up by soil mixed with dry farmyard manure from time to time. The plants should be watered regularly every alternate day and in dry weather every day. It is better to loosen the soil around the plants once a week which conserves the soil moisture better. Application of a table-spoonful of ammonium sulphate or ammophos, a commercial fertilizer, to young plants will induce a vigorous growth.

When winter vegetables are to be grown, there should be a good source of water supply near by. This purpose may well be served by digging a *katcha* well in a suitable corner of the garden and fenced properly.

Insect pests—During the seedling stage mole-crickets, cut-worms and red ants cause a considerable damage. The gaps should be filled up from time to time. It is quite easy to find out the whereabouts of a mole-cricket from the new earth that comes out from the holes in the land near by. They should be dug out, if possible, by a *kodali*. The crickets can easily be brought out in a few minutes by filling the holes with phenyle or kerosenised water.

In advanced stage of growth cabbages are attacked by cabbage-worm, which is a caterpillar of a butterfly. They can be easily detected by their greenish excreta on the rolled leaves of cabbage heads and should be picked up by hand. Dusting with ashes will check them.

When cut-worms and red ants damage the crop, it is always advantageous to adopt the flood system of irrigation or furrow irrigation with a little crude oil, mixed at the source of water supply, which controls them to a large extent.

Cauliflower, turnip and knol-khol are grown in the same way as cabbage.

Beans

The country beans are the common vines, growing in every home. They are sown in individual raised beds, sufficiently manured in August to October. The seedlings are to be protected from the pumpkin bugs. The vine requires trailing on a bamboo lath (Jhānkā). Beans are obtainable in the market from December to April.

There are a good number of varieties, having different colour, size and shape under various names. They should be saved by fencing from stray cattle. They do not require any care except manuring and watering in the dry cold weather.

The English beans such as French beans, string beans and runner beans are also found to be grown to a certain extent. They are to be sown in October (when the rains are over) at a foot apart in ridges. They grow well in the hills almost all throughout the year. In case of string and runner beans some support is to be given on which they twine. There is a great demand for them in the market.

The land should be prepared thoroughly and manured well without which no good crop is expected. They require a good deal of care. No weeds should be allowed to grow and the base of the plants kept loose by occasional hoeing. They may be watered by furrow irrigation or by a watering can.

Peas

Country peas *(matar)* are grown in the field especially in the new alluvial soils. The green peas are sold as *matar shooti* and have a great demand in the market. Under Assam and Bengal conditions, they are to be sown in October. They do well in a clay loam or sandy clay soil. In low-lying silted area they can be broadcasted well, but a thorough preparation of the soil and manuring are needed to insure a good crop, when grown in a high land.

English peas are generally grown in gardens to a certain extent. They are sold green at very high prices. They are to be sown in

ridges in October after the rains are over at 6 inches apart. The seeds are very susceptible to water-logging. The vines should be trained on bamboo sticks or a woven bamboo fence, made for the purpose. Liberal application of manure and watering is essentially required to grow a successful crop. Occasional hoeing is necessary to remove the weeds and loosen the soil at the base.

Pumpkins

Among the climbing vegetables, pumpkin (*Kumrā*), gourd (*Lāu*), white gourd (*chālkumrā*), cucumber (*shashā*), bitter gourd (*kerelā*), snake-gourd (*chichingā*), Luffa (*Dundul* and *Jhingā*), *patal* etc. are the most common. All of these vine plants need a support and a bamboo top or a lath (*Jhānkā*) is all that is necessary for them. They should be sown in March and April with the first shower of rain. The time for their sowing is given in Appendix VI.

The seeds of different varieties should be sown separately in a well-manured circular bed (*Tāoa*) with a liberal supply of water. The most suitable place for them is the proximity to the manure pit. They should not be put in a low place where they are liable to be water-logged. They are grown as a *Kharif* crop except the pumpkin and cucumber, which can be grown all the year round provided the flood water does not affect them. The bank of a village tank or a ditch (*nālā*) is a good place for them. There are some varieties of pumpkins and gourds that can be grown in the silted paddy fields as a *rabi* crop, where the individual plants do not occupy very much space. The *khira*, water-melon and *kharbuz*, which are used as fruits, are grown in the same way. When grown carefully, these vegetables give a good profit and supply the food requirements of the family.

The pumpkin beetle is a common pest that causes a considerable damage to the young seedlings. For this semi-circular wire gauze cover may be made as that used in the kitchen to save the food from the flies. Similar bamboo covers may be made for the purpose. The seedlings are to be kept covered until they give out several strong leaves. Dusting with kitchen ash is also helpful to a certain extent.

The Kachu

Among the root vegetables, the *kachu* is a common one. It is found to grow almost anywhere. The most important varieties are Man kachu, Naga kachu, Mukhi kachu, Ol-kachu and Pani kachu All of them, except Pani kachu, grow well in a loam soil

in a higher level. The Pani kachu is grown by the border of ditches, silted tank, ponds and marshes. For this purpose suckers and rhizomes are collected and planted in the mud in winter.

Generally kachu is a potash-loving plant and a liberal application of ash is always necessary for it. Man kachu will do well where the kitchen ashes are thrown out. Both farmyard manure and ashes are to be mixed together and ploughed under, while planting the kachu in the field. They are to be earthed once and no weeds should be allowed to grow in the field.

The Sweet Potato

The sweet potato is a profitable root crop, grown almost everywhere in Assam and Bengal by the cultivators. There are two varieties of sweet potatoes, commonly known to cultivators—the white and the red. The sweet potato can be grown in any soil but it does well on a sandy loam. The land should be ploughed deep for it.

Sweet potatoes are easily propagated from cuttings, but the roots are also used. The cuttings are to be planted in ridges or beds in August or September. Those, planted in the rains, give a vigorous vegetative growth and serves the purpose of a cover crop. The thickened roots that are used as food are formed, when the rains are over and are harvested from December to February.

Yams

Yams are a very good root vegetable. They are planted in March and April in isolated places where they can get a support to climb up a tree. Big holes should be dug out, filled with sufficient manure or leap-mould and the tops of the yams with a few buds should be planted in them. Bamboo poles may serve the purpose of support under field conditions. When once planted, they do not need any more care. They respond well to manure and ash.

QUESTIONS :

1. Name the English and the country vegetables, you know and state the seasons when they are grown.
2. What is the difference between a root crop and a tuber crop? Give an example of each.
3. Where does the major portion of potatoes come from in Assam and Bengal? How are they transported?
4. How can you store potatoes for the seed purpose in the plains?

5. Why should you select your potato tubers before planting?
6. Have you ever seen the potato plants being killed by blight? How can you control it in your own garden?
7. State plainly what vegetables you have grown at home and how they did?

LABORATORY EXERCISES:

1. Plan out a vegetable garden at home in consultation with your teacher and with the approval of your guardian.
2. Plan out a vegetable garden in your school compound in consultation with the teacher.

N.B.—If there be a chance to have a school garden, the teacher may start to grow winter vegetables when the rains are over. The plan of the work should be made ahead.

CHAPTER XVII

THE TOBACCO

The tobacco is extensively grown in Northern Bengal, and to a certain extent in Lower Assam Valley. This crop is really very important in Rangpur, Jalpaiguri, Dinajpur and Cooch Behar districts of Bengal where the people sell their tobacco to the middlemen who own large curing sheds. After curing, the tobacco leaves are packed and despatched to Calcutta. There are different varieties of tobacco of which the Matihari, Bhengi and Deshi varieties are found to be grown in Eastern Bengal and Assam.

Soil and climate—Tobacco thrives best in a well-drained friable sandy laom soil where there is sufficient organic matter. The silted low-lying areas of Bengal and Assam grow it well. It may well be used as a rotation crop with jute or aus. In upper Assam it is very often damaged by late rains in seed bed and by early rains during maturity. Both Kamrup and Goalpara are well suited for tobacco cultivation on a large scale.

Cultivation—Cultivation for tobacco should be deep and a thorough pulverization of the soil is necessary to clear away the weeds and make the soil loose. Irrigation is necessary, if there be no rain and this should be followed by a light hoeing. In a clayey soil, repeated light hoeing is necessary. During hoeing the plants may well be earthed up once which will make them stand better.

Sowing seeds—Tobacco seeds are sown in August and September. In Assam and Eastern Bengal this has got to wait till the end of September or early in October. The seedlings are generally transplanted when they are about a month old. About half-an-ounce of seed is required to plant an acre. Sufficient ash and farmyard manure should be used in a seed bed. Seedlings are transplanted when they give out the second pair of leaves and are about 2½ inches to 3 inches high. They should be watered almost daily for a few days and shaded with banana sheath after transplanting.

The seedlings are very often cut by mole-crickets and sometimes by cut-worms. Care should be taken to kill them. The seedlings are planted at 2½ to 3 feet apart each way which depends on the nature of growth of the varieties.

Manuring—Tobacco responds very well to manuring with chilli saltpetre, superphosphate and ashes. The farmyard manure is universally used no doubt, but the application of a commercial fertiliser will be quite paying in tobacco. Moreover, green manuring with dhaincha or cowpea gives very good results. This can easily be done after early jute or *aus*. It is known that the use of farmyard manure deteriorates the quality of cigar tobacco and hence, artificial manures in as little a dose as possible should be used. The application of potassium sulphate, calcium carbonate and gypsum is very useful.

After care—When the plants begin to flower, their buds and lower leaves are to be stripped off, otherwise the leaves do not grow in size. The lower leaves, removed may also be dried and sold as poor grade tobacco. When the leaves begin to mature, they turn yellow with brown spots, having a gummy feel to touch. They should be harvested at that stage in the morning when the dew is off the plants. The whole plants are cut at the base and left in the field for a couple of hours and then taken to the drying shed.

In the drying shed the plants are hung up on strings until they are quite dry. Usually it takes about two months. This is known as 'curing' of tobacco. During this time a process of fermentation goes on which improves the flavour of the tobacco. Improved methods of curing was started in the Tobacco factory at Cooch Behar long ago. The leaves are sorted out and tied up in bundles. After about two months, the leaves become thoroughly cured when they are ready for packing and sale. Cigarette tobacco is produced by flue curing in which the temperature is kept under control in an especially prepared barn.

Collecting seed—In order to get a good seed-supply, a few healthy and stout plants are allowed to go to seed. After maturity, the plants are cut, allowed to dry and then the seeds are taken out. The seeds should be dried well and then put in a dry phial with a tight cork.

Yield—The general outturn of tobacco is about 20 mds. per acre which depends on the soil and the climate. Matihari, Bhengi and Pusa varieties become successful all over Eastern Bengal and Assam. They not only yield higher than the local ones but get a better price in the market. A maund of ordinary tobacoo sells at Rs. 5/- to Rs. 8/- per maund. This means that an acre of tobacco will fetch Rs. 100/- to Rs. 160/-. At present an attempt is being made by the Department of Agriculture in Bengal to introduce the cultivation of cigar tobacco varieties, for which there is a great demand in the market.

GENERAL QUESTIONS:

1. What is the time for sowing tobacco seeds in your district? State briefly how you make a seed bed.
2. Do you know when leaves are picked? State briefly how to cure tobacco leaves.
3. How can you increase your income in tobacco-growing?
4. State briefly the products made out of tobacco.

LABORATORY EXERCISES:

1. Collect samples of different varieties of tobacco leaves and keep them as herbarium specimens.
2. Grow a line of tobacco and cure the leaves, when ready.

CHAPTER XVIII

THE SUGARCANE

Sugarcane is an important crop both in Assam and Bengal. The raw sugar (*gur*) and sugar (*chini*) are the two articles of daily use in every home. Sugarcane is mostly grown in uplands where the flood water does not affect the crop (Fig. 43). Both United provinces and Behar are important for sugarcane cultivation. The area under sugarcane is about 38,000 and 233,400 acres in Assam

FIG. 43. Sugarcane field, Jorhat.

and Bengal respectively. Owing to protective tariff, enforced by the Government of India on foreign sugar (Java), its cultivation is rapidly increasing and it is believed that India is going to be self-sufficient in this commodity in near future.

Soil—Sugarcane grows on a wide range of soils, but it thrives best in a rich loamy soil with a light admixture of sand. Although its cultivation is found mostly in the neutral or slightly acid soils of riparian tracts, it is also grown in the old alluviums where the soil is distinctly acidic in nature. Virgin soils or cleared jungle lands always give a good crop.

Preparation of soil—Sugarcane requires a deep ploughing, without which no satisfactory results are obtained. In large scale cultivation, the use of a tractor is very useful and economic, otherwise improved iron ploughs should be used. The land should be ploughed at least four times. In clay soils the clods should be broken well, the land is to be harrowed then and all the weeds, particularly the roots of thatch grass should be removed. Care should be taken for proper drainage all round the field as well as inside, as need be.

Planting and manuring—In planting sugarcane attempt should be made to collect disease-free setts of improved varieties, such as Poj 2714, Poj 2878, Co 213, Co 290 etc., either from Government farms or from neighbours. With the present low prices of gur, it is no use to plant the local varieties, such as the Mug, Teli or Kheri canes, which seldom make good *gur*. Trench system of planting is the best and so, long trenches should be made in the field about a foot wide, 9 inches deep and 4 feet apart. Closer planting may be done with thin canes. 200-300 mds. of cowdung and 500 lbs. of oil cake should be applied in trenches which depends mostly on the nature of the soil. The manure in trenches should be mixed up with a hoe and then setts should be planted at end to end, each sett having 3 eyes or buds. Whole canes of the Coimbatore varieties can be planted, if desired, but this involves the risk of wide incidence of insects and diseases. The trenches should then be filled up with soil and packed on the surface. 10 to 12 thousand setts are required to plant an acre.

Sugarcane is generally planted in March-April, but early planting always gives better results. Planting may begin in January with the early canes and may be continued to March or April. In case of early planting one irrigation is necessary to help the cane setts to germinate well.

Earthing—When cane shoots grow up to about 2-3 feet, it is necessary to earth them up. Then again when the canes grow from 5-6 feet high, which is attained within a couple of months, another earthing up is required. During this second earthing it is always advisable to apply a surface dressing with another dose of oil cake at the same rate as before. Earthing not only makes

the canes stand erect, but it checks the growth of weeds, loosens the base of canes and aerates the roots. Weeds, especially those of thatch grass, should not be allowed to grow by the cane clumps. If necessary, they should be controlled by a hand weeder.

Both in Assam and Eastern Bengal the sugarcane is a rain-fed crop. This is really a distinct advantage to the cultivators of these two provinces in comparison to those of Bihar and United Provinces. With the depression in the jute trade, there is no reason why they should not take sugarcane as a good substitute crop on suitable soils.

Harvesting—Canes are generally harvested from January to March. Late harvesting is always detrimental to the ratoon crop, which is so important in Assam and Bengal. In large scale cultivation, one should grow both early and late canes so that harvesting and *gur*-making may be continued for about 4 months or so without any difficulty.

Crushing—In crushing the canes, the 3-roller iron mills serve the purpose best for ordinary cultivators, as they are easily worked by bullocks. When adjusted properly, they will give about 70% extraction of juice, although generally only 60% on the weight of the cane is obtained. The price of a 3-roller mill will cost about Rs. 55/-. In large plantations, the use of power crushers, run by an oil or a steam engine is necessary. An ordinary crusher with a Diesel oil engine will cost about Rs. 1,300/-. Such a crusher will crush about one ton of cane per hour. As cultivators cannot possibly buy such a machine, it would be better if private owners or societies (co-operative or agricultural) buy a machine for hiring purpose in important sugarcane centres.

Gur boiling—The juice extracted is first filtered through bamboo baskets or wire sieves and then boiled in large *gur*-boiling pans, which should be covered at the bottom with a plaster of mud so as to protect the *rab* from burning. The recent introduction of Hadi's process or Rohilkhand *bel* is not only economic, but gives *gur* of high quality. Installation of one such *bel* will be good for 50 acres of sugarcane or more. Cultivators should work on a co-operative basis both for crushing and *gur*-making. When the juice begins to boil, the scum should be constantly removed. After a certain period, some wild or cultivated lady's finger (*dheresh*) or simul bark should be used as a clearing agent. When the juice attains a certain consistency, called the *rab*, as indicated by solidification on cold water, it should be readily poured in Kalsis (earthen pots). For safe keeping *gur*

may be put in kerosene tins with the top soldered which will keep *gur* for a long time in good condition. Paraffining the earthen *kalsis* also serves the same purpose for which the cost is nominal.

Sugar is mostly manufactured in factories. Big factories are found in United Provinces and Behar. There are also a few factories in Bengal, producing white sugar. A large quantity of sugar (brown) is manufactured from *rab* or *gur* with the help of centrifugal machines. Such a sugar has a demand in the market and fetches a better profit than *gur*. Sugar candy is another product of sugar.

Yield—The average yield of stripped cane, as obtained by cultivators, is about 20 tons per acre which make about 32 mds. of *gur*. At present this fetches a price which seldom covers the cost of cultivation. With the introduction of superior varieties and under proper cultivation and manuring, the average yield will go up to 30 tons per acre which will give a profit.

Ratoon—In Assam and Bengal, plant canes are generally ratooned in the 2nd year, which, when properly earthed and manured with cowdung and oil cake as surface dressing at the rate of 200 mds. of cowdung and 10 mds. of oil cake, will yield over 25 tons of stripped cane per acre. It is not advisable to grow a second ratoon in the 3rd year, which along with lowering the yield, increases the incidence of borers and fungus pests, which are detrimental to cane cultivation. Consequently, the land after the first ratoon crop should be ploughed and hoed and other crops are planted in rotation or green manuring tried to recoup the fertility of the land.

Rotation—In growing sugarcane in an area year after year, one should adopt a well-regulated system of rotation. As sugarcane is a heavy feeder, a 4-year rotation will do well. After the second ratoon crop, it is advisable to plough up the whole area and grow a green manuring crop of sunn-hemp, *dhaincha* or cowpea. This should be followed by a winter crop of either oil seeds or pulses. The land should then be put under another green manuring crop and then fallowed until the cane is planted.

Enemies of sugarcane—The jackals, wild boars, parrots and sometimes elephants near a forest are great enemies of canes. There should be a good jackal-proof fencing. A narrow ditch, outside the fencing is a good check to wild boars. The cultivators should always look for high-yielding and jackal-proof canes.

Borers are a great pest to sugarcane. Burning of stubbles and trash right in the field after harvest and rotation are the two

feasible remedies that can be adopted by our cultivators. Moreover, there are some fungus diseases such as collar rot, red rot etc. which spoil the canes very badly. Care should be taken to plant disease-free setts after selecting them by hand before planting.

QUESTIONS :

1. Is it possible to grow sugarcane in your district ?If so, state the advantages and disadvantages.
2. Why is rotation so important in sugarcane cultivation ?
3. How would you manure and plant the sugarcane setts ?
4. What care would you take for :
   a. collection of setts for planting ?
   b. combating the borers and diseases ?
5. How would you know the maturity of canes ?
6. How would you store *gur* for long keeping ?

LABORATORY EXERCISES :

1. Visit a sugarcane farm during planting and harvesting season when *gur* is boiled.
2. Collect samples of different varieties of canes and try to identify them.
3. If possible, visit a sugar factory which produces brown or white sugar.

CHAPTER XIX

THE JUTE

All of you are familiar with jute which is the most important fibre crop of commerce in Bengal and Assam. The area under jute is about 2½ million acres, of which 85% are grown in Bengal and about 6% in Assam. There are two important species of jute, viz., the Capsularis and the Olitorius, both of which are being grown commercially. The former is grown mostly in Eastern Bengal and Assam and the latter in the Western Bengal.

Soil—Except in laterite and gravelly soils, jute can be cultivated in any kind of soil, but it thrives best and is profitably grown on loam or rich clay soils, mixed with sand, as it is met with in the riparian tracts of Bengal where it is cultivated most. The best quality of jute is obtained from soils which are loamy in nature and are above the flood level. Submersion of the base generally induces adventitious roots which deteriorate the quality of jute. Both geographical and climatic conditions offer an ideal condition for growing jute on a commercial scale in Bengal and that is why Bengal has a monopoly in this commodity.

Preparation of soil—A good preparation of soil is essential for jute cultivation. The land should be ploughed 4 to 6 times according to the condition of the soil. The clods in clayey soils should be broken and the soil pulverized to bring it to a fine tilth. The work should begin in December or January after the paddy crop is harvested and may be continued even up to March.

Seed and sowing—The cultivators seldom care for selected seeds. They generally leave a patch in a corner or in the middle of a field for seed purpose and mostly use their own seeds. Successful attempts have been made by the Department of Agriculture, Bengal, to introduce improved strains, of which there is a great demand among the cultivators, as they get a better price for them. Kakiya Bombai and Green Olitorius are the two well-known varieties which are being widely distributed in Bengal and Assam. The sowing season extends from February to April and even up to May. About 4 seers of seed are generally broadcasted in an acre of land. Drill-sowing is desired for commercial cultivation, the rows being 9-12 inches apart and the plants at 4-6 inches apart. Thick sowing is the rule.

Weeding—Weeding is really very important in jute cultivation. This is required to be done two or three weeks after sowing. A good and handy weeding implement, the *Nirani,* is required for the purpose. This not only takes out the weeds but also removes undesirable seedlings and allows proper spacing as need be. Weeding should be given 2 or 3 times, which at the same time loosens the soil.

Manuring—In the silted soils of the riparian tracts, no manure is required for growing jute. In high land areas it is always better to use cowdung at the rate of 150—200 mds. per acre. Commercial fertilizers, such as Sodium nitrate and Potassium sulphate will increase the yield and quality no doubt, but under the present depression in the market, it can hardly be used with advantage. Trenching water hyacinth or the application of burnt water hyacinth ash is very useful.

Rotation—Like other crops, jute should not be grown year after year in the same land except in well-silted inundated areas. There is a custom of growing jute and aman (transplanted sail), one following the other in some localities in Assam and Bengal. Potato, pulses, oilseeds may well be grown after jute. A jute land should grow two crops any how.

Harvesting and retting—As soon as the flowers come out, it is time for harvesting the jute for fibre purpose. The time for harvest depends mostly on the time of sowing the seeds. It begins in June and extends up to October, the average season being from the middle of August to the end of September. Late harvest increases the yield but lowers the quality of fibre.

Jute stalks are cut at the base near the ground, tied into bundles, carried down to a pool of water and kept submerged until decomposed. It takes from 2 to 3 weeks or more which depends on the kind of jute and the nature of water in which the jute is steeped. Clear and stagnant water is known to be the best which is generally obtained in ditches on both sides of the railway lines or high roads. The fibre is then separated, washed and dried. The dried fibres are bundled and stored away or sent direct to the market or sold to the *Beparis* (middlemen). The jute is sold either to the commission agents or to the mill-owners who sort, pack and press the commodity in bales for shipment to England or elsewhere.

Yield—The average yield of jute per acre comes to about 12 mds. but yield of 15 to 20 mds. is not rare. As the cost of production comes to about Rs. 30/- per acre, no satisfactory

can be expected unless the price goes above Rs. 5/- per maund. With a view to fetching this price, a campaign for jute restriction to limit the production is already afoot.

Industrial uses of jute—The jute fibre is mainly used for: (a) making clothes of different qualities, ranging from substitutes of silk to shirtings, curtains, carpets and gunnies; (b) paper-making from the "rejection" and "cuttings"; and (c) cordage making. So you can easily understand how useful the jute fibre is. Both Calcutta and Chittagong are the two centres of export trade in jute. Jute is really the wealth and prosperity of Bengal and it should be improved so far as its yield and quality are concerned. Like the tea industry, the limitation of its cultivation will save the growers during this present market depression in price. There should be a jute Growers' Association in each centre in Bengal and Assam.

QUESTIONS :

1. Is jute a profitable crop now? If not, why? If so, why?
2. What kind of soil will grow jute well? Make a brief statement, regarding the locality where it is grown well.
3. Why is weeding so important in jute cultivation? How is the operation done?
4. How would you prepare the land for jute?
5. When would you cut your jute? State briefly the operations, done from field to mills.
6. State briefly a few good substitute crops for jute.
7. State briefly the uses of jute.

LABORATORY EXERCISES :

1. Take trips to the field to see the weeding and retting operations.
2. Collect samples of two classes of jute and note down the colour, gloss and softness of fibre. If possible, collect samples of different grades of jute from the market.

CHAPTER XX

THE COTTON

Of all the textile fibres, cotton is the most important article of commerce. Its cultivation is as old as civilisation and extends all over India, both in the hills and the plains. The rough short stapled cotton, namely the Garo cotton, is grown in the Garo and other hills of Assam and the Comilla cotton in the Chittagong and Tipperah hills. The fine long-stapled cotton is grown in Sind, Bombay, Central Provinces and elsewhere in India.

Next to jute, cotton is an important fibre crop in Assam and Bengal. The rough Garo cotton is exported to European markets where it is mixed with wool to manufacture a poor grade woollen cloth, known as "Shoddy" cloth. The famous *muslim* cotton, once produced in Bengal, has disappeared about two centuries ago with the deterioration of the trade. Attempts should be made to revive the cultivation of fine long-stapled cotton in Eastern Bengal and Assam.

Soil—Cotton grows well on rich, friable deep soil with sufficient humus in it. A warm climate, having about 3 months rainy season during the growing period, suits well for cotton. The rich black cotton or *regur* soils of Bombay, Madras and Central Provinces are well suited for fine long-stapled cotton. As water-logging is detrimental to its growth, it is rarely grown in the rainy plains of Eastern Bengal and Assam. It is, however, possible to grow in western Bengal with irrigation. Cotton will grow in the old higher alluvial tracts like the central part of Assam where the rainfall is low.

Sowing—The seeds are to be sown in March and May after one or two showers. The land is prepared well by ploughing and harrowing in February and March and the seeds are dibbled in lines about 2 feet apart and about 3 or 4 feet apart in between the rows. Two seeds are put in every hole and plants are singled out later. It takes about 5 seers of seed per acre. The seeds germinate in about a week. Furrow sowing is adopted where the land is dry so that the plants may be earthed up later. But in case the soil is rather wet, sowing on ridges may be done. In the hills cotton is grown with other crops, such as millets, maize and vegetables. A few *Bahamani* or *Deo Kapas* plants are found in every village, especially in the home of Brahmins who use this for their holy thread.

Aftercare—The field should be hoed to prevent the growth of weeds. The loosening of the soil helps in conservation of soil-moisture, especially during the drought. It is always better to fence the fields against stray cattle and wild animals.

Manuring—Except in virgin soils, the cotton will do well on manuring. Farmyard manure is always good for cotton both as basal and top dressings. However, nitrate of soda gives a better growth and higher yield, which is not commensurate with the present low market price owing to general trade depression.

Crop—The cotton begins to flower in October-November and flowering continues till January, if there is sufficient moisture in the soil. The bolls begin to mature in January and last till March. The cultivators generally pick the bolls of cotton gradually as they mature. The cotton in Assam and Bengal is usually packed in cylindrical bamboo baskets and is carried to the local market whence the dealers sent them down by carts to the steamer ghat for transportation to Calcutta. Chittagong, Mankachar and Goalpara are the three important trade centres of cotton.

Yield—The yield of cotton varies a great deal which depends on the varieties, the favourable climatic conditions of the locality and the richness of the soil. The yield of Garo cotton comes to about 200-300 lbs. per acre.

Ginning—Cotton is seldom ginned by cultivators. This is done by ginning and pressing mills. Selling unginned cotton is a real loss to the growers. Not only the price is lowered due to lack of any standard bale of cotton, but the loss of seed in unginned cotton deprives us of its by-products, namely, the *cotton oil* and the *cotton cake* which are two profitable products from cotton seed.

The common *Charki* (*Neothani* in Assamese), having two wooden rollers, is known all throughout India. It is very slow in action. The modern ginning machines are at work in many places in India. There are over 1,000 ginning mills in India which gin and press the cotton into bales. So you can easily imagine how important this cotton industry is.

Cotton Manufactures—For manufacturing cotton goods, there are two different devices, namely, the hand-loom and the power-loom. The hand-loom is found almost in any village and is the mainstay of many people, while factories with steam power loom are mostly found in Western India and a few in Bengal. All our *dhuties, Saris, Chadars* etc. are now made in India and a large number of mills

are running in competition with foreign mills. There is really a great hope in India for textile industry in future.

Uses of cotton—The cloth, we wear and use in our homes, is mostly prepared from cotton. The indigenous *Charki* for ginning cotton, *Charka* (*Jatar* in Assamese), the Natai and the Tawkka (*Latai* and *Takura* in Assamese) for making the thread are found almost in every village. These are largely used to weave rough cloth. In Assam hand looms are found in every house which are looked by women. The *Tantis* of Bengal make fine *saris* and *chadars* in many places from imported thread. At present we mostly use *dhuties, saris* etc. which come from the Indian mills.

QUESTIONS :

1. What do you understand by textile industry ?
2. Is there any cotton cultivation in your village ? If so, please state how and for what purpose they are grown.
3. Is it a loss to sell unginned cotton ? If so, why ?
4. What are the two by-products of cotton in a ginning factory ? Name them and note their utility.

LABORATORY EXERCISES :

1. Collect different samples of cotton, both leaf and boll, if available, and make herbarium specimens.
2. Sow a line of cotton seeds in your school garden and note their growth and boll formation etc.
3. Visit a ginning factory or cotton mill, if possible.
4. Try a country gin (*Charki*) to gin the cotton.
5. Get a *Natai* and *Tawkka* (*Latai* and *Takura*) and try to make thread, if possible.

CHAPTER XXI

THE TEA

Many of you are perhaps accustomed to taking the morning cup of tea, though not familiar with the tea plant itself. The common tea, as you know, is the young shoot of the tea plant which is botanically known as Camelia thea. In India tea is extensively grown in Assam, Bengal (Duars), Madras and to a certain extent in Burma. It is a very important agricultural commodity and its plantation is the only agricultural enterprize that has been so well-organised by Europeans in India. Tea is manufactured with the help of well-developed machineries which require a big capital to start with. Many Indians have started tea gardens in imitation of the European planters (Fig. 49) and are really successful.

FIG. 49. A tea garden, Jorhat.

Soil and climate—Tea will grow in a wide range of soils provided they are well-drained but it thrives best in a light, deep, sandy loam soil. A stiff clay soil should be avoided, as such a soil

gets hard in winter and water-logged in summer. In Assam where the monsoon rain prevails, sufficient care is taken to dig draining ditches in the garden at about 30 feet apart.

The humid climate of Assam and Duars, having a temperature of from 75° to 95°F during the hot summer days, is really very favourable for tea cultivation. Tea may be grown in the foot hills when other conditions are favourable, but it does well in the plains.

Propagation—Tea is generally propagated from seed. For this purpose, tea seeds are collected from plants which are left without any pruning to produce seeds and when allowed to grow in the natural way, a tea bush becomes a tree within a few years. The seeds do not keep well for a long time and so should be sown in the same season when they are harvested.

Tea seedlings are to be grown in heavily manured nursery beds about 4 feet in width. The seeds are planted about a foot apart. October is the best time for making the nursery so that the seedlings may be planted in the garden next winter.

Planting—The land for tea should be thoroughly prepared by ploughing and harrowing. A motor tractor is always useful in breaking up a new land. Tea plants are generally planted 4 feet apart. At first the land should be staked and holes dug out. The seedlings are then balled and deposited carefully in the holes. A tree transplanter helps the operation very well. Transplanting should follow the early showers in March and April.

Manuring—The farmyard manure is the most common material to manure tea plants. It may be applied at even 500 mds. per acre. As cattle manure is scarce, oilcakes may be substituted for it at the rate of 10-12 mds. per acre. Commercial fertilizers, such as Sodium nitrate, superphosphate and basig slag etc. may also be used to advantage. Moreover, very good results are obtained by green manuring with legumes, such as matikalai, dhaincha, sunnhemp etc. A tea grows in acid soils, liming is not necessary.

Pruning—As the growth of new shoots and more leaf area is to be encouraged in tea plants, they are generally pruned well and the operation is done in winter when the plants remain rather dormant. The first pruning begins after the first year of planting in the field and the plants are cut at about 8 inches from the ground. On the 3rd year the plants are again cut back to 14-18 inches of the ground and after this light pruning is adopted. Old trees are heavily pruned to rejuvenate them.

Hoeing—Hoeing is necessary to control the weeds as well as to loosen the earth around the base of the bushes for good aeration. A clean culture is always desirable and consequently 2-3 light hoeings are required in addition to one deep-hoeing in winter.

Shade trees—Tea plants are found to grow well under partial shade of other trees and so Sissoo (Dalbergia) and Siris (Albizzia) are planted at 30 feet to 40 feet apart, which save the trees from the hot sun and help in checking the evaporation of the soil moisture. It is better to grow leguminous plants such, as *arhar* and *bogamedaloa,* which secure an additional benefit of nitrogen supply.

Plucking—Tea is plucked almost all the year round. The first plucking commences in March. This is continued up to October which is the time for getting the highest yield. After this, the crop gradually diminishes until December when the plucking stops. The tea plants give a full crop from the 6th year. 700 to 800 lbs. of green tea leaves, per acre are the normal yield, but when the soil conditions are favourable it may go up to 1,200 lbs. per acre.

Insect pests and fungus diseases—The most important insect pests of tea are :—

1. *Red spider*—It causes considerable damage to tea plants. It should be controlled by dusting powdered sulphur by a good blower.

2. *Mosquito blight*—The mosquito, which is responsible for the mosquito blight, causes the most serious damage to tea bushes. Spraying with kerosene or crude oil emulsion is the only method to control it.

There are a few diseases in tea, of which the following are worth mentioning :—

1. *Red rust*—It is caused by an alga and can be controlled by spraying with Bordeaux mixture.

2. *Fungus blights*—The blights can be controlled by spraying with sulphate of lime.

There are also the tea-canker and the root-rot which are of bacterial origin.

Manufacture of tea—The manufacture of tea from the green leaves involves the use of complicated machineries for curing, drying, sorting packing etc. which have improved the tea industry

to a great deal of perfection. There are two classes of manufactured tea, the black tea and the green tea. In India the black tea is the only marketable product. Moreover, there are different grades of tea, viz., the Flowery Orange Pekoe, Broken Orange Pekoe, Orange Pekoe, Pekoe, Fannings, Broken Tea, Souchung and dust. The tea dust is also sold at a comparatively low price.

GENERAL QUESTIONS:

1. State briefly the origin of tea.
2. Where can one find land for tea cultivation?
3. Why is the question of labour so important in tea cultivation. Where do the planters get the supply of labour from?
4. Why do you prune a tea plant? What do you understand by collar pruning?
5. What is the food value of tea? Why is it that doctors advise the children not to drink it?
6. What is the obstacle for an ordinary individual to start a tea garden?
7. Does it pay to start a tea garden? State briefly how one can make prosperity and wealth in tea cultivation.
8. Is it possible to grow a patch of tea around the homestead for the family supply? If so, how?

LABORATORY EXERCISES:

1. If you reside in a tea district, visit a tea garden and note how this commodity is manufactured.
2. If tea leaves are available, try to prepare, if possible, some hand-made tea in your school.

CHAPTER XXII

ROTATION OF CROPS

Experience shows that if one crop alone is grown in a field year after year, the yield decreases a great deal. This is the case with most of our crops, such as sugarcane, potato, jute, maize etc. For this reason it is necessary to grow crops in succession so that one crop may follow another systematically. This method of cropping is known as rotation of crops. It is an important factor in agricultural practices. A successful grower should always follow it regularly.

Cultivation of one crop of paddy in the same field has been the cause, not only of depletion of soil fertility but has increased insect pests and diseases in our cultivated fields. The fertility of the soil can hardly be maintained unless rotation or change of crops is practised and it is only the application of heavy commercial fertilisers that can partially achieve the object of rotation, but the latter is too costly for the Indian cultivators.

Utility of Rotation

A well-regulated rotation plan effects the soil in various ways as follows :—

a. Recuperation of the soil fertility :—

Each particular crop takes up from the soil one or other of the nutrient elements more than the rest and in doing so, if the same crop is continued for several years, it makes the soil deficient in that particular nutrient and makes it quite unfit to grow the same crop any longer. If another crop is grown in the same field in rotation, which does not use the same nutrient elements as the other, the exhausted soil will recuperate its fertility and both the crops will grow satisfactorily. Generally we find that sugarcane can successfully be grown in the first year as a plant cane and it can be continued for the next year as a ratoon crop. But on the 3rd year, if it is ratooned or sugarcane is planted in the field again, it will give a poor outturn which will hardly pay the cost of production. But, if the field is ploughed and cultivated thoroughly and another crop, such as *dhaincha*, sunnhemp, cowpea, *matikalai* or groundnut is grown either as a green manure or as a grain crop, it will replenish

the soil to allow a good plant cane in the 4th year. Green manuring with *dhaincha* or cowpea is always desirable to improve the soil and give a satisfactory outturn, as they not only add humus and nitrogen but improve the tilth of the soil as well.

b. Liberation of the plant food—

Rotation liberates the plant food and renders it available to the plants. A change of crop and a consequent cultivation for the purpose of crop production break up the chemical constituents of the soil which thus become available to the crops grown. Consequently a rotation of the important crops, such as jute, rice and potato with *dhaincha*, *matikalai* or *khesari* as a green manure will improve the present status of agriculture in Assam and Bengal.

c. Control of the insect and fungus pests-

Some of the crops are more susceptible to insect or fungus attack than others and each particular crop has its own natural pests which starve to death for lack of suitable host plants, when another unfavourable crop is grown. Such is the case with the Phytophthora infestans (Potato blight) in potatoes, *Ufra* in paddy, weevil in *arhar* and caterpillars (Semi-looper) in jute. In such a case a suitable rotation with other crops, especially legumes, will do away with the insect or the fungus trouble.

d. Control of the weed—

Rotation with short crops, such as the legumes, used for grains or for green manuring, will control the growth of weeds. Owing to copious rainfall the high lands of Assam and Bengal become often covered with many kinds of persistent weeds. In such a case a root crop, such as radishes, sweet potatoes and turnips will help in controlling them. Moreover, a legume, such as the *bogamedeloa* (Tephrosia) will control even the thatch grass which is very difficult to eradicate.

A four year rotation course has been followed very successfully in sugarcane cultivation in the Jorhat farm in Assam for the last 25 years as follows :—

1st year.	2nd year.	3rd year.	4th year.	5th year.
Plant cane	Ratoon cane	Green manuring with legumes both in summer and winter.	Summer crop (preferably a legume). Fallow (in winter).	Plant cane.

In some parts of Surma valley and East Bengal the cultivators follow some kind of rotation as follows :—

	Assam and Bengal	Eastern Bengal
a.	Aus potato, linseed, til, groundnut or *matikalai*.	Sail Matikalai, *Khesari* or Mustard.
b.	Jute potato, til, sunnhemp or onion.	

A cultivator should plan a definite system of rotation with a fodder crop in addition that will supply his stock and maintain the fertility of the soil. He should also try such crops that can be sold in market without much difficulty and give him a chance to get some ready money to meet the expenses of his cultivation. A programme of crop rotation may be planned for two, three or four years as need be.

Considering the number of crops grown, there might be many ways of rotation for our cultivated crops. The following courses of rotation, may be used by the cultivators of Assam and Bengal :—

Nature of soil.	1st year	2nd year.	3rd year	4th year.	Remarks.
A. High land (not inundated).					
Sandy ..	(a) Plant cane	Ratoon cane	*Arhar* or maize	Legume Fallow.	
	(b) Jute or Aus Potato, legume, oilseeds or winter vegetables.		Legume or oilseeds		

Nature of soil.	1st year.	2nd year.	3rd year	4th year	Remarks.
Loam ..	(a) Plant cane (b) Jute or Aus Potato, legume, oilseeds or winter vegetables.	Ratoon cane	-Do-	-Do-	In very clay soils which dry & crack badly, no rabi crops will grow. But, however, when soil conditions permit, it is advisable to grow some legumes in rotation.
Clay ..	Aus Sail	...	...	...	
B. Low land (Inundated)					
Sandy ..	(a) Jute or Aus Pulses, potato or winter vegetables.	...	...	...	In an inundated silted area all the crops can be grown provided the flood does not interfere.
	(b) Aman or sail Pulses, oilseeds, or winter vegetables.	...	...	...	
Loam ..	-Do- (a & b)	...	...	...	
Clay ..	(a) Aus or jutes Potato or winter vegetables.	...	...	...	
	(b) Aus (with Aman), Aman or sail Pulses, oilseeds etc.	...	...	...	

QUESTIONS :

1. What is the utility of rotation ?
2. Why is it that sugarcane, banana and pineapple plants do not bear profitably after the 3rd year, while in rice it is not so appreciable ?
3. Plan a four-year rotation course with sugarcane.
4. What causes the soil to be exhausted of fertility after a crop is grown repeatedly ?
5. When a proper rotation is not possible, what should a cultivator do to keep up the productivity of the soil ?
6. Why should legumes be better used in rotation ?

LABORATORY EXERCISES :

1. Study the rotation of crops, followed by the cultivators of your village.

CHAPTER XXIII

MANURES AND FERTILISERS

By growing continuous crops, the soil is robbed of its fertility. This is especially the case when two or three crops are grown in the same land year after year without any addition of plant-food in the soil which always causes a lower yield of crops. This is quite evident in the case of growing vegetables in the kitchen garden. Such an exhausted soil can be replenished by the application of manures and fertilisers. Of the former, the cowdung is well-known, while the latter includes commercial products, obtained in the market, such as bonemeal, sodium nitrate, ammonium phosphate etc.

Manures and fertiliser, help the cultivation of crops in several ways, viz., (1) by improving the physical condition of the soil: (2) by supplying plant-foods in the form of nitrogen, phosphorous and potash, and other necessary constituents for the growth of plants and (3) by helping the growth of bacteria in the soil that change the different constituents of plant food into available form.

In growing a crop successfully, the soil should contain an adequate amount of the three important elements—the nitrogen, the phosphorous and the potash. A diminution in any of these essential elements from the minimum, required for plant growth will result in a failure of crops.

Nitrogen is the most important of the plant foods. Although it constitutes four fifth's of the air, it is not available to plants freely. A plant can only take the nitrogen from the soil by one of the following methods:—(1) by the use of commercial fertilizers, (2) by the nitrogen fixing bacteria and (3) by the addition of humus to the soil either as green manure or the application of organic manures.

The three important classes of fertilisers that may be applied in the soil for the successful production of crops are: (1) the nitrogenous fertilizers—sodium nitrate, sulphate of ammonia and calcium cyanamide etc. (2) the phosphatic fertilizers—bonemeal and superphosphate of lime, ammonium phosphate etc. (3) the potassic fertilizers—sulphate of potash, muriate of potash, nitrate of potash etc.

Commercial fertilisers—The agricultural value of commercial fertilisers depends on the percentage of nitrogen (N), Phosphoric

acid (P_2O_5) and Potash (K_2O), they possess and also upon the solubility of these substances, when applied in the soil. The percentage of these substances can easily be calculated from the molecular weights of pure materials.

(*a*) *Nitrogen* (*N*)—Nitrogen occurs in free state in atmosphere as ammonia (NH_3) which contains about 82.3% of nitrogen. Sodium nitrate, ammonium sulphate and calcium cyanamide contain 16.4%, 29.2% and 35% nitrogen respectively. The sodium nitrate, supplied by the chillian Nitrate committee is the most common nitrogen fertiliser and is widely used.

(*b*) *Phosphoric acid* (P_2O_5) —This substance is found in combination with calcium and oxygen to form chemical compounds, such as Rock phosphate and bone phosphate. Phosphoric acid contains 43.6% of phosphorous, whereas bonemeal, super-phosphate of lime and ammonium phosphate contain 45.7%, 28.3% and 36.4% of phosphoric acid respectively. Basic slag which is so commonly used is an artificial preparation. Its use in acid soil is beneficial especially for its power of reducing the acidity of the soil. The recent introduction of ammophos, Lunaphos and niciphos is gaining favour among the vegetable gardeners.

(*c*) *Potash* (K_2O) —The potash supply in fertilizers is obtained from potassium sulphate, potassium chloride, potassium nitrate and wood ashes and the percentages of potash (K_2O), they contain are about 48%, 50% 45.5% and 12% respectively.

In fact, the standard fertilisers, sold in the market are generally labelled in regard to the percentage of the fertilizing ingredient, for which it is intended. Thus, when of standard purity, sodium nitrate contains about 15% nitrogen and ammonium nitrate about 20%; while the rest of the materials, that are mixed up in fertilizers are mere fillers, i.e., ingredients which are not of any direct use to plants.

Special fertilisers, which are a mixture of one, two or all the three fertilizing ingredients, viz., nitrogen, phosphoric acid and potash are sold in the market.

Application of fertilizers—In applying commercial fertilisers, one should find out the requirement of the soil for the particular kind of crop. Different crops take up one or other of the plant

food materials more or less. This can only be found out by chemical analysis. Moreover, the cultivator shall have to consider the cost of applying fertilisers and the profit, he is going to make from the increased outturn.

The best indication that a soil is exhausted of its fertility can be obtained from the poorer growth and less outturn. Where the decline of fertility is thus recorded, one may be sure that either the nitrogenous or the phosphatic fertilizer is required, because the potash salts are generally found sufficient in our cultivated fields. No fixed rule can be followed in the application of fertilizers. Experience is the best guide.

Farm-yard manure is a balanced fertilizer, containing each one of the above three elements and is the best form of fertilizer for the crops and the most easily available material for our Indian cultivators. This should be collected in a covered pit in the form of a compost and is to be used after it has decomposed well. It should be applied liberally at the rate of 200-350 mds. per acre according to the nature of the soil as well as the crop produced.

Artificial manure may be made by composting the litter, farm sweepings and refuses, all being put in a shallow pit where these materials are collected and urine is poured on it from time to time. In six months' time the material gets rotten which may be used then as a manure in the field. Besides these, oil cakes, although constilier than the farmyard manure, can be applied to improve the physical condition of soils and supply plant foods. In fact, when cattle dung is scarce, oil cakes can largely meet the demand of organic manures. In addition to manurial value, some oil cakes act against the incidence of insect pests. Castor cake is a deterrent to white and red ants and so is a good manure for potato and sugarcane. All cakes should be soaked in water and farmented before application, specially in dry season.

GENERAL QUESTIONS:

1. What do you understand by farmyard manures, fertilizers and compost and what is the utility of their applications?
2. How would you know that your soil requires manuring? At what rate farmyard manure should be applied?
3. What are the three limiting factors for plant growth and why?
4. What are the three important kinds of fertilisers? Name them with examples.
5. How would you apply farmyard manure in the field, in the vegetable garden and in the orchard?

6. Is it harmful, when a basket of fresh cowdung is applied right at the base of a tree? If so, how would you use it?

LABORATORY EXERCISES:

1. Make two similar plots. In one, apply well-rotten cowdung at the rate of 300 mds. per acre, and keep the other as a check. Grow *matikalai* or paddy and note the results.
   a. Which plot gives the best result? Why?
   b. When should you apply cowdung? Why?
2. Make a list of all the fertilizers that are available in the market.
   a. Do you know of any one using any one of the above named fertilizers? With what result?
3. Apply some farmyard manure or fertilizer in the form of a ring about 1½ to 2 feet away from the base of some fruit trees and note the results.
4. Visit a tea garden or a fruit orchard and note the method used in manuring and fertilizing the same.

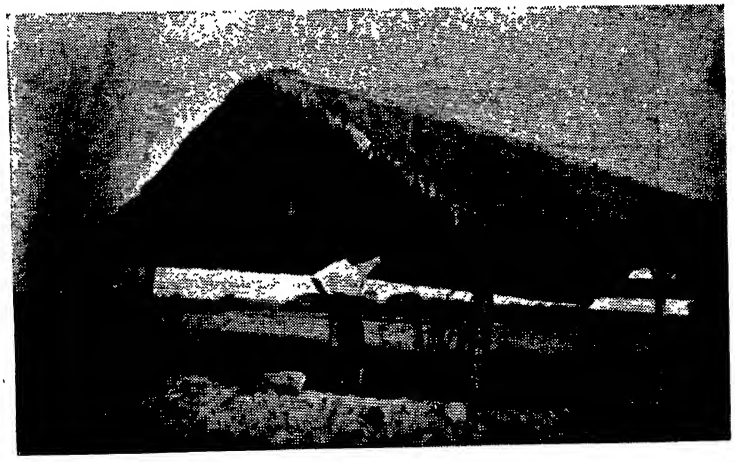

FIG. 49A. A covered manure pit (vide p. 164).

CHAPTER XXIV

WEEDS

Plants that grow by themselves in a place where they are not wanted are called weeds. They are an enemy to cultivated crops, as they rob the crops of soil moisture and food. They also harbour insects which cause a considerable damage to crops.

Weeds are soil indicators. They show the nature of soils and their relation to water in a particular place or locality. You always find that the herbage in a low-lying damp meadow will be quite different from that of a highly situated land even in the same locality. The poor acid character of the soils in Assam and parts of Bengal can be recognized by the growth of phutki (Melastoma) plants and thatch grass, which are found to grow in poor waste land and not in the fertile cultivated areas (Fig. 50.) In order to

FIG. 50. A typical waste land covered with Phutki (Melastoma) and thatch grass (Assam).

bring under cultivation, such a land should be ploughed deep so as to uproot the thatch grass and the phutki and manured and limed well so as to make it suitable for crop production.

Classification of weeds—According to the duration of their growth, weeds may be classified as (1) Annuals; (2) Biennials and (3) Perennials.

(1) *Annual weeds*—Annual weeds propagate from seeds, flower and fruit and complete their life in one season. The *Aghra*

(Xanthium), *Sialkanta* (Argemone), *Bishkatali* (Polygonum), *Kaṇtanotya* (Amaranthus) etc. are the common examples of this class of weeds. The cultivator should cut them off or pull them up before they go to seed.

(2) *Biennial weeds*—Biennial weeds live for two seasons. They propagate from seeds, complete their vegetative growth and store food in the thickened roots in the first year. In the second season the plants thrive, go to seed and die. They are wanting in our tropical countries but are found in cold climates where the activity of the plant ceases due to cold weather. The Carrot beet and rutabaga are the field crops that come under this group. Dandelian (Taraxacum), thistle (Cardvus) and Moth mullein (Verbascum) are examples of biennial weeds.

iBennial weeds can be killed by pulling up the roots or by cutting off the plants before they go to seed. Persistent cutting off the top close to the ground will kill them.

(3) *Perennial weeds*—Perennial weeds grow from seeds, rhizomes, runners, stolons and bulbs. They flower and fruit every year and continue to live for several years. The *Mutha* (cyperus), *Pishach* (Eupatorium), *ulu* (Imperata). *Phutki* (Melastoma), *Chorkanta* (Andropogon), *Kush* (Eragrostis) etc. are the examples of perennial weeds. They should be eradicated by pulling them by the roots. If the plants are cut persistently close to the ground 2 or 3 times during the year, the roots will be killed in course of three years.

Dispersal of weed seeds—Weed seeds are dispersed from one place to the other by various agencies such as wind, water, transportation of goods, animals and manipulation of man. Of these the wind is mostly responsible for their rapid dispersal. You might have noticed in a clear day in autumn how the seeds of composite flowers, such as Thistle, Eupatorium and *ulu* with their white fuzzy pappus are blown by wind. The seeds of Eupatorium are known to travel even 100 miles from their place of origin. This obnoxious weed is now found to grow widely on both sides of the Assam Bengal Railway line.

QUESTIONS :

1. What is a weed ? Classify weeds with an example of each class.
2. What is the best way to kill weeds in the field ? In the orchard ? In the vegetable patch ?
3. How are weeds harmful to crops ?
4. Where do the ordinary weeds grow most ? Why ?

LABORATORY EXERCISES :

1. Dig out the roots of a small orange tree where thatch grass is growing and notice how the roots of grass clamp the roots of the tree.
   a. Are the grass roots injurious to the orange tree ? Why ?
   b. Do the weeds rob the plant food and moisture ? How ?
2. Make a collection of weed seeds and put in small phials.
3. Make a collection of weed plants and preserve them. *

* Use newspaper for this purpose. Cut the paper to 18 inches × 12 inches size and get two wooden boards about an inch thick. The paper with the specimen should be put in between the boards with a brick on top as a weight.

CHAPTER XXV

INSECT PESTS AND DISEASES

The crop plants, we grow, are very often attacked by insect pests and diseases, the latter being mostly of fungus origin. The common cultivators in India consider them as providential ordain and so they seldom try to adopt any remedial measure In order to grow crops satisfactorily for profit, one should try to control them. Very often you notice in your vegetable garden that some sort of caterpillars grow on the leaves and defoliate them, and the red ants and the cut worms spoil the potato and other root crops. On the other hand, blight (Phytophthora) and Rhizoctonia cause entire failure of potato and the *Pan* crops respectively. Unless some suitable means is adopted to check the ravages of insects or fungus diseases, it is not always possible to get a satisfactory crop.

1. Insect pest

An adult insect has a head, a thorax or chest and an abdomen made up of several round ring-like sections. It has six legs, attached to the thorax and usually four wings. Butterflies and moths have four wings and house flies have only two. There are some insects, such as the mole-crickets, ants etc., which are wingless. Insects breathe through the little pores (spiracles) on their abdominal sides. In the development of their life cycle most insects pass through four stages of growth—the egg, the larva, the pupa and the adult. Of these the larval form in some is the feeding stage of the insect. You might have noticed this in rearing Eri or Muga worms.

The insects that cause damage to our crops belong to two separate classes according to their feeding habits: (*a*) Biting insects and (*b*) Sucking insects.

a. *Biting insects*—The biting insects have biting mouth parts, having Jaws (mandibles), with which they chew the leaves upon which they feed. The grass-hopper, pumpkin beetle and mole-crickets are good examples of this type (Fig. 52). They can be killed by food poison as follows :—

1. Paris green.

Paris green	..	1 lb.
Water ..	..	50 gallons.

2. Lead arsenate or lead chromate.

Lead arsenate or chromate	.. ..	1 lb.
Water	.. .. ..	50 gallons.

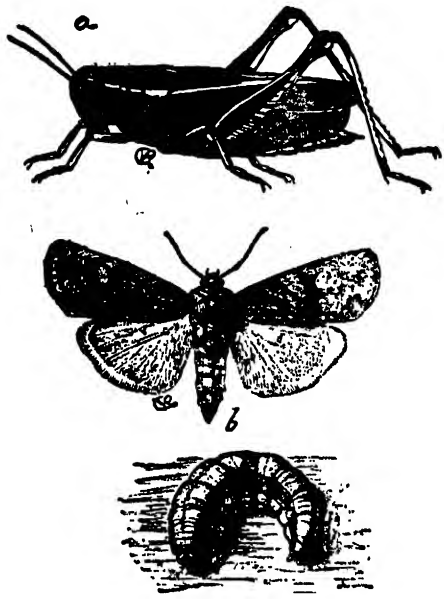

FIG. 52. Biting insect (after Relay).
a. A grasshopper with biting mouth parts
b. A cutworm (adult) with sucking mouth parts
c. A lava of (*b*) with biting mouth parts

It is better to add 4 lbs. of lime in each case before use so that the solution may not injure the leaves.

Among the biting insects, the borers are a common pest to sugarcane, orange, jack fruit and other trees. It is not possible to poison them when once they get an entrance in the trunk. In order to check them to get up on the trunk of a tree, it is better to white-wash the base of the trees up to 3 feet from the ground and put a cotton or straw band. This will prevent them from crawling up the trees. A coat of tar in the form of a band is also useful.

b. *Sucking insects*—The sucking insects do not have biting jaws. They have a long beak or tube, by which they suck the sap from the inner tissues of the fruit, leaf or stem. The ordinary plant lice, scale insects (Fig. 53) are good examples of this type. They are not affected by food poison. So they are to be killed by contact poison, such as spraying with some chemicals or powder

which will corrode the tough covering of their body or close their breathing pores. For them the following are useful :—

1. Kerosene emulsion.—

Soap	½ lb.
Water (hot)	1 gallon.
Kerosene	2 gallons.
Water	30 gallons.

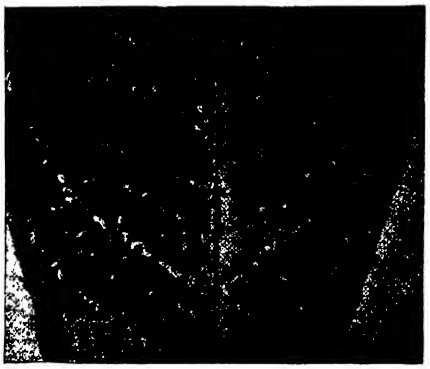

Fig. 53. Sucking insect. Orange leaf attacked by soft scales (after Quayle).

Soap should be dissolved first in hot water and then kerosene added to it. The mixture should be stirred for 10-15 minutes. Reserve this solution for future use. Dilute 10 times with water when the emulsion is to be sprayed on the plants. Suitable hand sprayer may be obtained from the market for the purpose at Rs. 1/8/- each. For farm work, a Knapsack or a Hudson sprayer will do better (Fig. 54).

2. Crude Oil emulsion

This is an emulsion of 20% of soft (fish oil) soap with eighty per cent of crude mineral oil (containing kerosene). This is used as a standard contact poison and the ready-made material is sold for mixing with water in the proportion of 1 to 60 parts of water.

2. Diseases

Diseases in plants are caused by (*a*) fungus and (*b*) bacteria.

a. *Fungus diseases*—Fungus diseases include mould, toadstools, smut and rust. They are propagated very rapidly by dust like particles, called spores, which float in air and settle on

and food stuffs where they grow. You might have handled a moulded orange and have noticed the dust coming out of it. These are the millions of mould spores. The potato and *pan* blights are two good examples, which are serious pests to potato and *pan* crops in the hills and the plains of Assam and Bengal.

Control of fungus pest—The proverb "Prevention is better than cure" is the slogan in dealing with the fungus diseases. So, such remedies should be applied that will prevent the growth of the organism. For this, Bordeaux or Burgundy mixture is very useful.

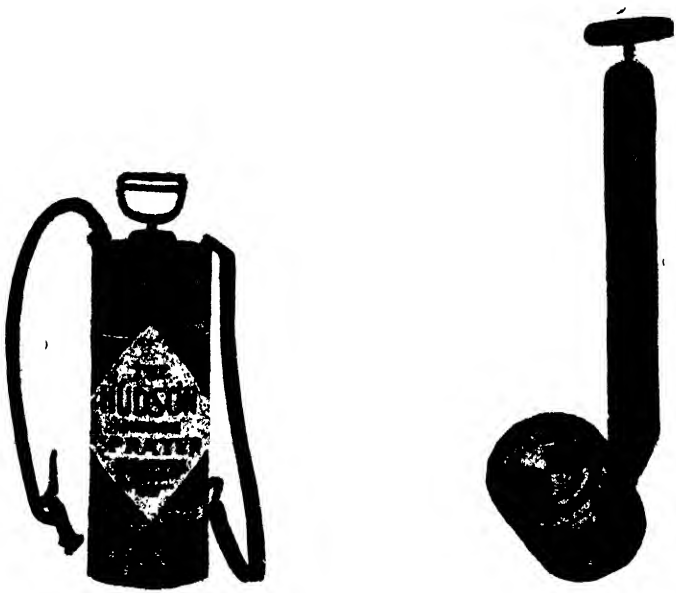

Fig. 54. Two kinds of sprayers.

Formula :

1. Bordeaux mixture.—

Coper sulphate	..	..	4 lbs.
Lime	..	..	4 lbs.
Water ..	..	..	40 gallons.

2. Burgundy mixture.—

Copper sulphate	..	..	4 lbs.
Washing soda	..	..	4 lbs.
Water ..	..	..	40 gallons.

In making the Bordeaux mixture, get three barrels and put sufficient water in one and hang the copper sulphate in a piece of cloth in it so as to dissolve it easily. Put the same amount of water in another and slake the lime. When the copper sulphate has dissolved and lime has slaked well, pour equal quantities of each in the third barrel. It is better to strain the two solutions before they are mixed up. Burgundy mixture is made in the same way.

Testing the solution—Put a drop of a 10% solution of yellow prussiate of potash to the surface of the mixture. It will turn reddish, if there is too much copper, and in that case more lime must be added to the mixture. But if it remains yellow, the mixture is all right for use. Moreover, the solution may also be tested by dipping a clean knife which will turn reddish, if there be an excess of copper in the solution.

In spraying potatoes or garden plants, an ordinary Knapsack sprayer is quite useful. As the spores often remain in seeds and soil during their resting period, as generally found in potato (phytophthora) and *pan* (Rhizoctonia), it is better to treat seeds and soil as the case may be, with their specific fungicides before sowing or planting.

Although insects are as a rule injurious to crops, there are some carnivorous insects among them which are beneficial to farmers in as much as they feed on injurious insects. The lady bird beetle, feeding on the Sanjose scale is a well-known example.

Apart from the insect attack in the field, farmers sustain a heavy loss year after year owing to some insect pests that attack the stored grains such as the weevils in rice. As a precaution against it, the seeds for sowing purpose should be dried very well and then put in earthen jars, covered with a *sara* (earthen top), plastered tightly with mud or flour paste. The common method of storing rice in a *topla* (bundle of straw) and keeping it hanging from the ceiling of the kitchen is really a very good practice. As for the ordinary grains, they should be stored in an earthen *dol* (cylindrical container). An wooden top, made to fit the mouth of the *dol*, snugly and tied with a piece of cloth will prevent the grains from the attack of moths and weevils.

b. *Bacterial diseases*—The bacterial diseases are not so prominent in plants as in animals except in a few cases. The common bacterial diseases are the bacterial rot in potato tubers, tobacco, and the cirtrus-canker. The attack of the bacteria kills the plant entirely in a short time. They are very difficult to

control. The only remedy in such a case is to uproot such a plant and burn it so that the disease may not spread.

QUESTIONS :

1. Do the insects and the fungi cause any damage to our crops ? How ?
2. What do you understand by the life history of an insect ? Explain
3. How do you control the biting and the sucking insects ?
4. Name some common insects that damage the crops in your locality and briefly state the methods of their control.
5. What would you do to control the borers in brinjal and orange shoots ?
6. Why is the prevention of a disease better than its cure ?
7. What is meant by hybernation and where do the mango weevils and the mosquitoes go during the cold winter months ?

LABORATORY EXERCISES :

1. Get some lemon caterpillars, cabbage worms and put them with sufficient green leaves in glass jars covered with perforated lids and notice the changes. Supply fresh leaves every day.
   a. What do these changes (metamorphosis) mean ?
   b. How do you account for the caterpillar and the pupal stages ?
2. Collect insects and preserve them in cigar or home-made card-board boxes. Use ordinary pins to hold them up.
3. Draw the mouth part of a grasshopper and a house fly.
   a. How do they take their food ?
4. Go to a field where a wholesale damage has been done to a crop by any insect or fungus ? Give a short description of the same.

CHAPTER XXVI

INSECTS OF ECONOMIC IMPORTANCE

There are a few insects of great economic importance that form a part of the cottage industries in Assam and Bengal. They are the lac insects, silk worms and honey bees. Of these, the lac is important mostly in the hills, the silk in the plains of Assam proper and in the north western Bengal and the bees in Khasi hills.

A. Lac Culture

A minute hemipterous insect (Tachardia lacca) produces the lac which is a resinous secretion of its body and remains incrusted on the twig. (Fig. 55).

FIG. 55. Lac culture on Ber trees (after Misra).

Life history—The insect lives on sucking the juice of the food plants on which they grow. The viviparous larvae of the insects come out of the lac incrustation in July and December and swarm around to settle down on twigs. The adult females have no power of locomotion and remain under their incrustation which grow in a special shape around them, while the males get wings and come out to fly around and visit the females.

After swarming the female larvae become fixed in a place and their legs fall off. A resinous secretion then begins to form around their bodies which ultimately encrust the twigs. At this stage the body of the females become enlarged and after reproducing several hundred offsprings they die. The males come out and fly about. The young larvæ swarm at a fixed time and in this way two broods are produced yearly.

In propagating lac, one has to lop off a few twigs of well-formed lac before the swarm of the larvae. These are tied in other trees where the larvæ become fixed in a short time. The lac is generally collected in two seasons, viz., May and June, and October and November.

Food plants—The insect is known to feed on a good number of plants, of which the *palas* (Bhutea), *dumur* (Ficus), *sal* (Shorea), *kusum* (Schleichera) and *Bor* or *Bogori* (Zyzyphus) mostly grow in the jungles; but *arhar* (Cajanus) in Assam and *babul* (Acacia) in Sind are also used for lac cultivation. It may also be mentioned here that the host trees require judicious pruning and hoeing around the base so as to keep up their vigorous growth.

There are various commercial products of lac manufactured in the lac factories in Bengal and United Provinces. The painted and pattern lac works of Mirzapur (U. P.) and Burma are well-known. The lac dye and resin are important commercially. The stick lac is used in sealing letters and postal bags.

B. Silk Culture

The silk culture in India is as old as the civilization and although the silk-worms are reared in almost every province in India, the important centres are found in Bengal, Madras, Bombay, Punjab and Burma. In Eastern Bengal and Assam the silk culture is an important cottage industry.

Various kinds of silk-worms are used for the production of silk. They are grouped under two sections:—(1) mulberry-feeding silk-worms and (2) the non-mulberry-feeding silk-worms.

Those, which feed on mulberry plants, produce the best white fine silk, commonly called the *pat* silk, while the rest, feeding on other plants except mulberry produce the rough buff coloured silk, called the *Eri* or *Muga*.

1. Mulberry-feeding silk-worms (Bombyx spp.)

They are the domesticated silk-worms, reared in many parts of India. The smaller or multivoltine (Bombyx croesi) and the larger or univoltine worm (Bombyx textor) both feed on the mulberry and produce a fine white thread. The eggs are laid in numbers and the larvæ, after hatching, begin to feed on leaves. After a time they form cocoons, within which the chrysalis stage is spent, and in due course the winged moth comes out of the cocoon which, after mating, lays eggs and dies. Thus the life cycle of the moth is complete. The four stages viz., egg, caterpillar, chrysalis and moth constitute one generation. The insects that take a year to pass through these stages are called the univoltine and those that have two or more generations in the same period, the bivoltine or multivoltine.

2. The non-mulberry feeding silk worms

The non-mulberry feeding silk worms include the *tasar* (Antheroea paphia), *muga* (Antheroea assama) and *eri* worms (Attacus ricini). Of these, the first one is important in North-Bengal districts, Bihar and Orissa, and Central Provinces, while the latter two in Upper and Lower Assam districts.

The tassar silk-worms feed on a number of trees, such as *kanchan* (Bauhinia), *dhaura* (Zizyphus), *simul* (Bombax), *karanja* (Carissa), *jam* (Eugenia), *aswatha* (Ficus), *arjun* (Terminalia), *aranda* (Ricinus), *ber* or *bogori* (Zizyphus) etc. Seed cocoons may be collected from the jungles and tied on the trees, as is done by the hill people, the Santhals of Bengal and Choto Nagpur. Specially selected cocoons are reserved from the previous year's supply for the purpose of seed. The males are allowed to move freely, while the females are tied by the thorax and exposed to open air where they may be visited by the males. The eggs are laid in the baskets which are then put on the trees. The pairing of the moths may thus be accomplished under confinement but the feeding of the larvæ must be done in the open air. The Santhals are naturally well-adopted to rear the tassar silk-worms.

The two kinds of silk-worms that are found to be most common in Assam and parts of Bengal are the *eri* and the *muga*.

1. *Eri silk*—The *Eri* worm is multivoltine and is reared in the house or especially made bamboo trays. After the eggs are deposited by the adult females, they are kept covered by a thin piece of cloth. They hatch in 15-20 days. The larvæ are taken in a separate tray and are fed with castor leaves that are grown in the homestead area by every cultivator. The worms feed voraciously on the leaves and grow fast (Fig. 56). After a time they stop feeding and form cocoons for which straw or dried branches are supplied. Six to eight days are required to form the cocoons. After this, the adult moths come out from the cocoons in two or three weeks.

When the adult moths come out, they are collected in a basket for pairing. After this, the females are kept in the basket, while the males are thrown away. The cocoons are usually boiled in an alkaline solution and are then prepared for carding and spinning. Both the thread and the cloth have a great demand in the market.

2. *Muga*—The life history of the muga silk-worm is almost the same as the *eri*. Unlike the latter, they are not grown indoors. The larvæ are put on *som* (Machilus), *sualu* and *mezankori* (Litsoea) and *champa* (Michelia) trees. They require protection from birds and monkeys. After the feeding stage is over, the larvæ come down to the main trunk where they are collected on the straw band put for the purpose. They are then put on a bamboo tray to form cocoons, which takes about a week. After the resting period is over, the moths emerge. As the females are recognised very easily by their bulky size, they are secured by a thread, passed around their thorax, while the males are allowed to move freely in the house. After mating, the female moths are put in trays for egg laying, after which they die in 5 or 6 days.

Except for breeding purposes, the insects are killed in cocoons by exposure to the sun or the heat of the kitchen fire. They are then boiled in an alkaline solution and reeled. It is then carded and spun. The district of Sibsagar is the centre of *Muga* culture in Assam.

C. Bee Culture

Bee culture may be carried on either for pleasure or for profit. There are many places in the Khasi hills where the people make part of their living by bee-keeping. The demand in the market for honey warrants a systematic method of bee-keeping.

Variety—Two varieties of bees are generally found in India for honey production: (a) Big bee or rock bee and (b) the little

Fig. 56. Muga silk worms in *som* trees. Note the full-fledged larvæ coming down and are collected.

Of the latter, the apis indica, as it is called, is the only one suitable for domestication.

Location—The best location for bees will be a place where there is plenty of blooming nectar-bearing flowers, such as the orange and lemon. In the Khasi Hills, the citrus flowers supply the bees with sufficient nectar for several months and there are other wild flowers that help them during the rest of the year. It is better to get a good shade for the hives, if they are put in an open isolated place. They do well under shade of orange and other fruit trees in an orchard.

Hives—In Khasi hills hollowed tree trunks, cut in small pieces are generally used. The *chaur* (bastard sagu palm) trees are cut in small pieces and after removing the pith, they are also used as bee-hives. Such a crude process is not satisfactory. Anyone, looking for a profit in bee culture either in the hills or in the plains should have modern bee-hives. They can be made (at home) of kerosine tin boxes, provided one knows how to make them. (Fig. 57).

Fig. 57. Bee-keeping, Agricultural Laboratory, Jorhat.

A bee-hive is generally made in three parts separately: (1) The bottom or the floor board with four legs and a sloping one to serve as an alighting board in front of the narrow entrance; (2) The hive proper with four walls; (3) The top or roof. The parts

should be well-fitted on one another. Each hive contains 8-10 frames which are set there for the bees to settle and form their combs.

Character of bees—A colony of bees usually consists of one queen bee, the mother of the colony, and a large number of workers which build the comb, gather the honey and feed the young and the queen which is recognized by her abnormal size. The workers have no sexual function. The males or drones are of no use except in mating with the queen.

The combs which form the nest of the bees are made up of wax, secreted by the workers. In the hexagonal cells the bees rear the young ones and store the honey.

In a big colony the queens are reared in specially made cells with the provision of special food. When one new queen emerges out, the other queen cells are usually destroyed. At this time swarming occurs from a colony. In swarming, the workers carry their original queen with them and find new location under the caves of houses or big branches of trees. From here, if cared, the bee-keeper can catch them for his hive. The workers build a comb, the queen begins to lay eggs and in a short time the swarm becomes a big colony.

After emerging, the new queen bee flies within 5 or 6 days to be mated by a drone. Then she returns to the comb, takes the place of the old queen and in two days begins to lay eggs. Hereafter the queen never leaves the hive and her only duty is to lay eggs to multiply the number of population in the hive.

How to start a colony—The bees are available in the swarming season in December and January or a little earlier in the hills when they settle on cavities or branches of trees, dark deserted rooms and other places. An experienced hand can easily capture them and put them in a hive. The hill people generally capture the queen from the colony, clip the wings and then place it in a small container, besmeared with a little honey. This may be transferred in a bee-box. The colony will settle down and start their work.

Handling of bees—The bees should be handled in such a way that they are not disturbed in their work. The hives should be fixed tight and should not be jarred. Any rapid movement is annoying to them. The hives should not be opened unnecessarily. The best time for handling bees is cool morning and evening hours. Never handle them at night or in rainy days.

A few puffs of smoke from a cigarette make them easier to handle. In raising the lid, the operator should not stand in front of the entrance, but at one side or the back of the hive. In examining a frame, it should be held over the hive and the frame with the queen should never be put on the ground.

Transferring—In increasing the apiary, it is necessary to transfer the colonies in the moveable frames. This may be done well in January and February. It may, however, be done in any season especially when there is not enough bloom in the locality and the bees remain rather inactive. In this case, one ought to be sure that there is at least one queen cell in the frame that is being transferred, without which the colony will swarm out to its former place.

Feeding—During the rainy season when there is not plenty of bloom, the bees should be fed artificially with molasses or sugar syrup (2 parts of sugar to one part of water, slightly warmed). This will keep them in good condition and ready for the next bloom to work with fresh vigour. For this purpose, a feeding dish can be set up under the hive body.

Prevention of swarming—The bees generally swarm when they increase in their colony. In order to prevent it, there should be plenty of room in the hive and enough shade and ventilation. If necessary, an additional hive may be put in. Besides this, cutting out the queen cells and requeening with young queens prevent the swarming of bees.

Honey—Honey is gathered by bees in the form of nectar, secreted by flowers. It is transformed by the bees in their mouth and stored in the cells, which are sealed with capings of bees wax. Honey should not be extracted before a large number of the cells are capped. The honey is to be pressed out, strained and then bottled.

For commercial bee-keeping, the best way to extract the honey from the comb is the use of a centrifugal machine. This has the advantage of keeping the comb in tact which can be reset in the frame so that the bees do not require to rebuild the comb. Honey, extracted in this way, is obtained quite clean and lasts for a longer time in good condition.

Bees wax—Bees wax is secreted by the bees and used in building their combs. It is an important commercial product. The common method is to melt the combs after the honey is

extracted. Various products are made of the bees wax, of which the candle is very common in our Indian homes.

QUESTIONS :

1. State briefly the spare time occupation of the cultivators in your neighbourhood. Do you think that they require improvement in this line ?
2. Are the people in your neighbourhood engaged in lac, silk or bee culture ? If so, state briefly the methods, they follow.
3. What are the food plants for the lac, the *eri* and the *muga* silk-worms ? How to improve them ?
4. Make a list of the honey plants, visited by bees in your own locality.

LABORATORY EXERCISES :

1. Visit a locality where there is lac, silk or bee culture and take down notes on the methods, adopted by the people to run such an enterprize. If you are engaged in any one of these, try to make a good plan of the work, showing the financial position of the undertaking.
2. Try to make a bee-hive under the instructions of your teacher.

CHAPTER XXVII

RURAL HEALTH AND SANITATION

The rural health and the sanitation of our country have not yet been developed, although such attempts in towns have produced beneficial results. It will not be an exaggeration to say that one-sixth of our country population suffers every year from one or other of the preventable diseases. Of these, perhaps about three-fourths are engaged in agricultural enterprizes. Among them many cannot work in the busy season and consequently they can hardly maintain themselves and become homeless. Only by improving the rural health and the sanitation and launching a propaganda to educate the masses on these two important points, avoidable calamities that beset our poor people year after year can be removed.

Generally diseases come under two main classes: (1) communicable such as malaria, kalaazar, small-pox, typhoid, cholera and dysentery. These diseases are mostly carried by insects, such as the mosquito, the house-fly and the sand-fly. A good many men die prematurely of these diseases every year which can be prevented by well regulated campaign against them. (2) Non-communicable, such as dyspepsia, hook-worm and diabetes. Although there are no direct deaths from these diseases, yet the people, who are affected by them, are not quite fit to do their usual farm work. There is quite a number of men who are addicted to some kind of drug habits, such as opium, ganja etc. which deteriorate their health and make them inefficient for actual economic activities of life. These should be avoided.

Most of the diseases are caused by some very minute organisms, commonly known as "germs." They are the bacteria. They enter into the human system and produce diseases. They cannot be seen by naked eyes without the aid of a microscope. Even the ordinary cold that we are liable to catch at any moment is also caused by a germ.

The bacteria are parasitic organisms. Their growth is favoured by moisture, warmth, filth and dirt which abound in air and fly

around like dust particles. They are killed by sunlight, air, heat and antiseptics.

The bacteria enter our system either by mouth or by wounds and develop quickly, if the resistive power of the body is not strong enough to counteract them. The body loses such a resistive power by over-feeding, under-feeding and insanitary living. The secret of keeping a good health lies in saving one-self from the attacks of disease germs.

The sanitation of our country homes is so poor that it requires a speedy measure to relieve the ignorant people by hygienic propaganda. Each man should be made to realize a two-fold duties—one to himself and the other to his neighbours. He should be made to take necessary precautions to ward off diseases and avoid (when attacked) the spread of contagion among others. Certainly a patient with malaria, kala-azar, typhoid, tuberculosis or cholera is a great danger to his community. Such a patient should be segregated at once and steps taken that he may not be exposed to disease-carrying insects or other direct sources of infection and thus infect other people.

Whenever any epidemic or stray cases of a communicable disease occur, it is the duty of the community to take necessary steps to prevent its spread. Such a patient should be segregated at once and a doctor should be appointed to treat the case.

The best way to prevent the germs to get into the system is stated as follows :—

1. Do not drink water that is not boiled thoroughly and do so with milk.
2. Do not eat any stale cold food, especially meat, fish and vegetables.
3. Do not put your fingers in the mouth without washing, as many disease-germs come in contact with them in our daily work.
4. Wash your hands and mouth well before taking food.
5. Clean your house thoroughly at least once a week. Every nook and corner should be cleaned and kept dry.
6. Have plenty of air and sunshine in your house. Have sufficient windows.
7. Keep the flies off from the food by covering it with a bamboo or wire basket or cover specially made for the purpose.

8. Cover the fæces of your open privy with ashes and dirt every morning.
9. Always sleep under a mosquito curtain.
10. Do not expose yourself to the vicious bite of mosquitoes. Always try to cover your body with something.
11. Do not put dirt or wash in the tank where your drinking water comes from.
12. Drain out the stagnant water from ditches near your house, otherwise they will provide a breeding ground for mosquitoes.
13. Collect the cowdung in a pit every day and cover with dirt and straw; as this will prevent the flies from breeding. Always remember "Prevention is better than cure."
14. Whenever you get sick, call for a doctor or go to the charitable dispensary for treatment.
15. Get yourself vaccinated against epidemics.

QUESTIONS :

1. What do you understand by a contagious and an infectious disease? Give examples.
2. Why "prevention is better than cure"?
3. How can you start a campaign with the assistance of your neighbours to control the flies and the mosquitoes?
4. How do the flies and the mosquitoes carry diseases from one individual to the other? State briefly the life history of both.
5. What do you understand by "Hygiene" and "Sanitation"? How can you help your own people and neighbours in this respect?
6. What do you understand by "segregation of a patient"? What precaution should you take to nurse a patient, suffering from contagious and infectious diseases?

LABORATORY EXERCISES :

1. Collect a few wrigglers of mosquitoes from a stagnant pool. Put them in a tin can, half-full of water, under a piece of mosquito or wire net cover.
   a. Do you notice that some of the wrigglers float horizontally and others vertically? Which of them are anopheles, commonly known to be carriers of malaria?
   b. Put a drop of kerosene in a can, containing wrigglers. What is the effect?
   How long does it take for the wrigglers to become adult mosquitoes?
2. Get from the manure heap a few pupae of house-fly and put them in a jar with a little dry manure. Keep it covered and notice how they come out to be adult flies.
   a. Why do you see flies near a manure pit?
   b. How can you prevent the growth of flies in a manure pit?
   c. How long does it take for the pupæ to become adult flies?

CHAPTER XXVIII

FORESTRY AND FOREST PRODUCTS

The forest is an important factor in the development of our human civilization. It is the repository of many natural resources, such as the timber and fuel. It tempers the climatic conditions of a region and checks the washing of the soil, caused by heavy downpour and consequently checks the flood. The lesson, obtained by Spain and China from careless cutting down of the forest should open our eyes and we should be more careful not to rob a forest of its valuable timber and fuel. The ruinous system of *Jhum* cultivation in the hills should be restricted by law.

Careless felling of trees and forest fires cause the denudation of a forest. The damage, done by forest fires is really very great. For this reason the forest department takes a special care to cut fire lines in a reserved forest of valuable trees.

The organisation of the provincial forest departments in India and their systematic work are the results of long experiences. A considerable amount of money is annually obtained as forest revenue. The science of forestry is well developed in India. The industrial development of our country is in many ways based on forest products.

The science of forestry does not prevent the trees from being cut down for lumber, but it helps in judicious lumbering so as to cut the mature trees only and allow the young ones to grow in their place.

The flora of Assam and Bengal comprises the following types of forests, such as the evergreen forest, the deciduous forest, the swamp forest and grass lands.

The evergreen type of forest of Assam and Bengal occupies a major portion of the Himalayas, Cachar, Tipperah and Chittagong. The evergreen pines are found to cover a vast area in Darjeeling, Khasia hills (Fig. 58) and Manipur. Apart from pines a large number of plant families are found in this type of forest. Of these,

the most important genera are Dillenia, Anona, Magnolia, Guttifer, Legume, Ericad, Martle, Satin, Laurel, Euphorbia etc.

The deciduous forests of Assam and Bengal comprise the *sal* (*Shorea*) tracts and a major portion of the scrub forests mainly in Goalpara, Garo Hills, Nowgong, North Cachar Hills and Mymensingh district of Bengal. Besides *sal*, plants of different famillies are met with in this type of forest, viz., Lagerstroemia,

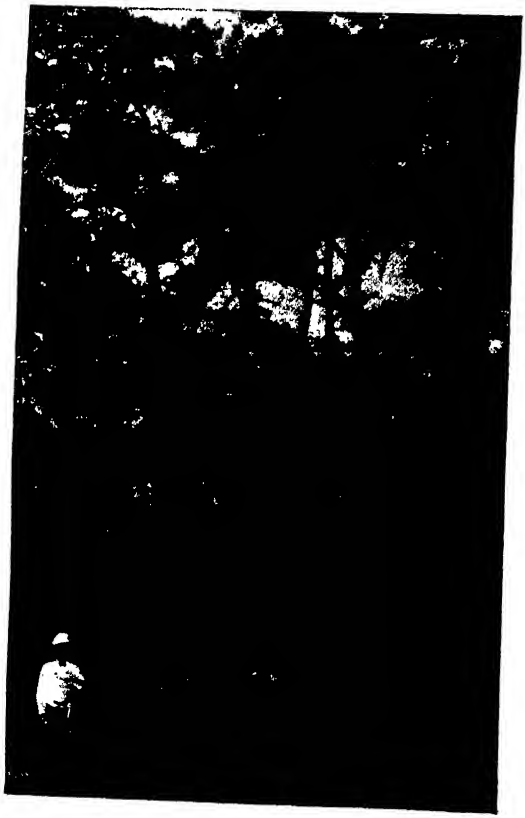

FIG. 58. A reserved pine forest, Shillong.
(Photo by L. Reade).

Cassia, Dalbergia, Gmelina, Albizzia, Ficus etc., and a certain amount of grasses.

The swamp forests are found in the plains of the Surma and the Brahmaputra Valleys and the delta land of Bengal. The great Tarai swamp near the foot hills of the Himalayas extends from the Punjab to Assam. The well known Sundarban is a typical swamp forest near the sea coast. A large number of trees and shrubs are

found in this type of forest. They are Crataeva, Eugenia, Sterculia, Heritiera (only in Sundarbans), Terminalia, Lagerstroemia, Trewia, Ficus, Clinogyne and a large number of grasses.

The grass lands of Assam and Bengal abound in a large number of genera, of which *khag* (Saccharum), *nal* (phragmites), *hogla* (Typha) and *ikar* (Erianthus) are important. They cover extensive tracts along the long rivers and attain a considerable height, while on the drier tracts they are rather smaller in size. They are common materials that serve many useful purposes in our homes.

The Government forests are divided into two classes, the "Reserved" and the "Unclassed" forests. The latter being *khasmahals* at the disposal of the Government are mostly covered by scrub forests. The areas under forest in Bengal and Assam are 3,778 and 18,509 sq. miles both for reserved and unclassed forests respectively.

The most valuable forest products are the timber and the fuel. Among timbers *sal* heads the list in the Northern and teak in the Southern India and Burma. Apart from this there is a number of other important timber trees, such as *nahor* (Mesua), *bansum* (Phoebe), *jarul* (Lagerstroemia), *sonaru* (Cassia), *sam* (Artocarpus), *gomari* (Gmelina), *khair* (Acacia), *sissu* (Dalbergia) and *gunserai* (Cinnamomum) and *sundar* (Heritiera). Timbers from them are important articles of commerce in Assam and Bengal.

The important minor forest products, that are being exported, are bamboos, canes, reeds, thatching grass, *agar*, lac, rubber etc.

QUESTIONS :

1. Why are forests so important in our human civilization ?
2. What are the important products that we get from forests. ?
3. What are the factors that determine a landscape to be covered over with large trees or grasses.
4. What do you understand by afforestation and deforestation ?
5. Why is it that floods increase with the denudation of forests ? Can you think of any method to control them ?

LABORATORY EXERCISES :

1. Take a trip to a *sal* or a pine forest, if possible, and get information from the Forest Ranger and Guards as to how they work.
2. Make a list of forest products and note down their utility.

CHAPTER XXIX

CO-OPERATION IN AGRICULTURE

Perhaps you know very little about the term "Co-operation". Co-operation in Agriculture means a combined effort of a group of agriculturists in a village or a group of villages to buy their requirements and sell their produce in common which is a great economy and power to regulate their transactions. In its widest sense it means the development of a community which may best be secured not by competition of individuals but by their mutual help for the good of the society or the community with the motto "Each for all and all for each." Thus the co-operative movement in agriculture is an attempt to form voluntary associations where individuals unite for mutual aid in the production and the disposal of a crop profitably. When such a co-operative association is formed, it can deal with rates of wages of labourers and import current prices in the market and other humanitarian and useful moves that are required for the development of a community or a group of villagers.

Co-operative movement is of recent origin in India. The Bengal Co-operative Organization Society was started in 1917-18. This year witnessed a considerable development of co-operative agricultural societies in Bengal. The best example of a successful organization in this line is the Naogaon Ganja Cultivators' Co-operative Society Ltd. which ousted the *ganja* brokers and placed the cultivation and sale of *ganja* on a sound footing. In 1931-32 the society sold 1,945 mds. of *Ganja* and 307 mds. of *Bhang* and made a profit of a *lac* of rupees. A considerable proportion of the profit was devoted to works of public utility, especially in schools and dispensaries.

There are two lines of co-operative societies known by the names of their originators, viz., the Reiffeisen system and the Schulze—Delitzsch Bank system. The former is mainly for the agriculturists which is commonly known as "Rural Banks" and the latter is primarily for the artizans and is called the "Peoples' Banks". In India co-operative societies have been started with the primary

The benefits, derived from the co-operative societies are two-fold, Viz., (1) the ryot is induced to save some money in the bank and dissuade himself from unnecessary expenditure over which he has generally no control and (2) to use some money for his agricultural enterprize without being indebted to the Mahajan, and thus to free himself from exhorbitant rates of interest which always means ruin. In developing agricultural activities, it is necessary to organize co-operative credit societies among the people themselves to help the individuals with some capital at very low rates of interest and that can only be possible for such a credit society, when well-organized. In fact, it requires the joint efforts of the honest educated workers and the Government. The direct benefit, attained by the people from an well-organized co-operative association may be stated clearly as follows :—

(1) It gives facilities to a poor grower to get the benefit of improved machineries, such as a power sugarcane crusher and gur boiling pans, irrigation pumps, cream separators etc.

(2) It will improve his live-stock, poultry and cattle and dispose of his produce very quickly without any loss.

(3) It facilitates the supply of good seed, manure, insecticides, fungicides etc., with the best advice for their use Cultivators cannot afford to get them individually.

(4) Such an association will be able to exercise some influence over transportation and marketing of the produce which will ensure the selling at profit to a certain extent.

(5) By disposing of the produce through the society or the association, the growers will do away with the brokers or the middle men and thus save some money.

(6) The society will be able to advance loans at low rate of interest which will help the grower in every way to carry on his profession on a better footing.

There are some societies, known as the non-credit agricultural societies which are merely purchase and sale societies and function

mostly as paddy sale societies, irrigation and drainage societies, the agricultural associations and production and sale societies, including the milk societies or unions. Among the paddy societies the Donovan rice mills, attached to the Sundarban sale society is a good example. This society, besides earning a handsome profit, successfully ousted the *Beparis* who had so long a monopoly on the paddy business and dictated the price which unorganized growers had to accept. There were 85 paddy sale societies in Bengal in 1932-33 with a membership of 11, 468, having a working capital of Rs. 6,61,000. Such societies should be organized all over Assam and Bengal in rice growing centres. The jute industry in Bengal and Assam should also be organized in the same way.

Among the non-agricultural societies, the most important are the Credit Stores and Supply Societies, Fishermen's Societies, Weavers' Societies, Silk Societies, Zamindary Societies to reclaim and colonise land, Anti-malarial and Public Health Societies, Women's Organizations, Relief Societies, Rural Reconstruction Societies, House Building Societies, the Bengal Home Crofters Association and the Bengal Insurance Society which by their number and variety evidently show how the co-operative idea has already entered the minds of the people. Among the higher co-operative organizations, mention may also be made of a few others, viz., the Provincial Co-operative Banks, the Central Co-operative Banks and the Land Mortgage Banks which are helping agriculture and other industries of the country.

The general economic depression as well as repeated floods have affected the co-operative movement both in Assam and Bengal. In the former the number of agricultural societies was 1,292 in 1932-33 with a membership of 52,204, while in the latter the number of agricultural credit societies was 20,009 with a membership of about 546,000 in the same year. The Nagaon Agricultural Association which is the largest of its kind in Bengal, maintains a farm of its own and has recently started a sugar factory.

Lastly, it may be said that the bulk of the rural population who are depending on agriculture alone will be benefited directly by the organization of co-operative credit societies and rural banks and their establishment in suitable centres is highly desired. They will not only be a great help to develop Agriculture as a profession by itself, but will enable our cultivators to make a living and stand on their own legs. It is also the duty of individual cultivator, growing some particular crop or crops to form a society and thus make it a stepping stone to better their own condition as well as

that of their neighbour. The Registrars of co-operative societies in each province have been trying to organize the societies throughout all districts, but unless the people realize the need of such societies and join the movement, the goal will never be reached.

QUESTIONS:

1. State briefly what you mean by "Co-operation."
2. What are the utilities of organizing a co-operative society or an agricultural association among the villagers?
3. Can you make a scheme of organizing a society in your village?
4. Meet a co-operative worker and try to understand the activities of a co-operative society. (The teacher may arrange a lecture by a suitable co-operative worker).

CHAPTER XXX

MARKETING OF AGRICULTURAL PRODUCE

All of you are familiar with the market in your village or town, but you know very little whence the commodities come, who deal in them and the price at which they are sold out by the growers and the price, paid by the consumers. You will easily realize the importance of good market, if you consider the prices of jute about 10 years ago when it was sold at Rs. 20/- to Rs. 25/- per maund and also the present prices of the same at Rs. 2/8/- to Rs. 3/8/- per maund. What the lower prices mean to the cultivators can easily be understood when you look to the present deplorable condition of the ryots in remote villages. The common depression in the trade in paddy and jute in Bengal and Assam and wheat in the Punjab and Sind has dealt a great blow to agriculture and agriculturists of the country and perhaps it will take a long time to recoup the loss.

Most of the agricultural produce, grown commercially by the cultivators in different localities in each province is taken to the market by the middlemen from whom the consumers buy them. This means that if potatoes are sold at Rs. 1/8/- to Rs. 2/- per maund by the grower where it is produced, the consumer pays Rs. 4/- to Rs. 5/- per maund. Thus deducting the cost of transportation, the middlemen get the best of the profit, while the price, obtained by the growers does not leave much profit for them. If the growers could have their own organization and agents to sell the produce direct to the consumers, they could make double the profit, while the consumers could get the produce at a cheaper rate. It so happens that during the harvesting season, the local markets are glutted with the produce, brought by individual growers. This reduces the price to a level which is below their cost of production. The produce that comes to the local market requires a systematic assembling, transportation, grading, standardizing, packing, storing and distribution. It is very often seen that a pineapple or a cabbage is sold at half-an anna in one district and at annas -/2/- to annas -/4/- in the neighbouring one. This means a lack of good transportation facility and regular market supply. The introduction of

systematic marketing facilities will help to set right such anomalous conditions.

The middlemen who deal in the marketing of goods may be included in any one of the three groups, viz., (1) private marketing agency, (2) co-operative marketing agency and (3) the Government marketing agency. The former two are in operation in our markets which functions as middlemen, while the latter is only operative on certain individual commodity under the force of necessity.

The growers in villages seldom care for kind, quality and size while marketing their produce. It is not very rare to see that two growers of the same locality carry the same produce in the same market, but one gets a price which is one and a half time the price, obtained by the other. This is mostly due to difference in grading and quality of the produce. The packing of farm produce is essential for distant market. For example, Queen pineapples of Sylhet, packed in boxes for Calcutta market will be sold for Rs. 25/- to Rs. 30/- per hundred, while the same commodity, packed in baskets with a gunny sack cover will not fetch more than Rs. 10/- to Rs. 15/- per hundred which does not give any profit. This is seldom realized by our Indian ryots. Organization among the growers and improvement of transportation facilities can only help in establishing a good market. So long there has not been any organized effort in those lines. Our growers are entirely ignorant of these facts and are not prospering at all.

Another great difficulty for the ryots is that they cannot store their produce. What to speak of perishable commodities, such as fruits, vegetables etc., they cannot store even paddy, oil seeds etc. for want of cash in hand. The establishment of warehouses, cold storage, and general stores for grains, oil seeds etc. is of utmost necessity to save cultivators during the season right after harvest. It is very often found that linseed and mustard are sold at Rs. 1/8/- and Rs. 2/- per maund in February and March, while after 2-3 months the price goes up to Rs. 4/-. Unless there are organizations for selling out the commodities in each particular crop, it will be difficult to save the poor ryots. Consequently, there is every necessity for financing the organization of a systematic marketing. It is with a view to facilitating the profitable disposal of agricultural commodities that the Imperial Council of Agricultural Research has started a marketing section in each province in co-operation with the provincial governments and it is hoped that within next 5 years, an appreciable improvement will be noticed. The educated public should help in this move.

QUESTIONS :

1. What is "marketing"? State briefly how the products are sold in your village *bazar*.
2. What would be the best way to sell the following perishable products : (*a*) Mangoes and (*b*) vegetables.
3. State briefly why *grading* and *good packing* are necessary to get a better price.
4. Meet a marketing officer, if possible, and know more facts about marketing of our agricultural produce.

CHAPTER XXXI

SOIL-EROSION AND SOIL-CONSERVATION

Vast areas of our country consist of hills. The agricultural productivity of these hills is being impaired to a great extent on account of soil-erosion and there are large tracts where this has already become quite serious. The people in the hills of Assam and Bengal should be fully alive to the causes and evils of erosion and adopt practicable measures to take up the work of soil-conservation.

Evils of Erosion

1. *Loss of Soil, valuable for agricultural purposes*—Land, subject to erosion, first of all loses the top layer of soil which is so valuable for the production of crops. This is followed by the removal of the subsoil and the lower strata down to the rock below. Thus, extensive soil erosion means ultimate destitution of the agricultural population. The danger to the inhabitants of the hills of Assam and Bengal is, therefore, evident. Moreover, there is soil-erosion going on continuously, though unperceived, in our homesteads and cultivated fields in the plains. Here also we should take preventive measures to conserve the soil.

2. *Drying up of springs*—Unchecked erosion makes land unsuitable for supporting the growth of vegetation and thus renders it incapable of absorbing much rain. As a result of this, the subterranean water supply falls off and it is this supply alone which feeds the springs in the hills during the rainless period of the year. So erosion in large tracts of the hills leads to the drying up of the springs in those tracts, as the water does not penetrate the soil underneath but runs off.

3. *Floods in the plains*—Soil, carried down by running water from the hills, particularly the coarser portion of it, is responsible for the silting up of the rivers in the plains. Rivers constitute the natural drainage system in any land and their choking up favours the occurrence of floods, particularly when large volumes of rain water quickly run down to the plains from denuded hills, as in

Assam. Thus, the question of soil-erosion in the hills is intimately bound up with the question of floods in the plains and it must be viewed as such.

4. *Deposits of sand in the plains*—The sand deposits, which are noticed here and there on the inundated river banks after the flood, are also among the evils of erosion in the hills. These render valuable agricultural land unsuitable for cultivation. Moreover, the sand deposits at the bottom of the rivers are not only making the river beds shallow but forming small *chars* (islands) in broader areas which impede the current and ultimately divert the river course, cutting and overflooding both banks.

Causes of Erosion

1. *Run-off rain water*—The immediate cause of erosion in the hills is the run-off of rain water. The potential power of this run-off for causing erosion depends upon its volume and accelerated velocity.

The volume of the run-off is determined by the amount of rain, falling in a given time and the amount, absorbed by the soil during that time. Torrential showers of rain, therefore, result in a large run-off. But it is hardly possible for man to prevent these natural forces.

The accelerated velocity of running water is governed by the slope of the land over which it runs. Levelling of the land or putting some kind of obstruction in the way would reduce its velocity and thus check erosion. A practical application of this fact in the hills would be to terrace the land under cultivation, wherever possible or make bunds along contour lines at intervals, when such land cannot be conveniently terraced on account of high gradient. Any quick-growing shrubs, thickly planted along contour lines will also serve the purpose of bunds.

2. *Destruction of trees and shrubs*—Deforestation destroys nature's device for the conservation of soil in hilly tracts and thus paves the way for erosion. The trees and shrubs, growing in a forest, afford mechanical protection to the soil by binding it with their roots and by breaking the force of rain. Moreover, a cover of forest enables the soil to absorb large quantities of rain water and thus reduces the volume of run-off. It also checks the velocity of the surplus water so that erosion of soil in a forest is always at a minimum.

In view of the above facts the method of *jhuming* or shifting cultivation, adopted by the hill people, is really a ruinous practice. This practice leads to progressive deforestation and is bound to result ultimately in large barren tracts in the hills and devastating floods in the plains (fig. 59). The menace of soil-erosion is already serious both in Assam and Bengal. The situation urgently demands necessary steps to be taken up by a joint effort of both the provinces.

FIG. 59. *Jhum* cultivation in hills and soil-erosion. (Note that the vertical beds invite more erosion of soil). (Photo by R. C. Woodford).

Control of Erosion and Conservation of Soil

1. *Control of erosion*—Control of erosion in cultivated fields can be effected only by substituting permanent cultivation for shifting cultivation (jhuming). Permanent cultivation on sloping land is possible only if it is laid out into terraces. Terracing has several advantages, though it requires much labour in the initial stage. Not only does it make shifting cultivation unnecessary, but it also makes possible the use of agricultural tools and manures with advantage. As already pointed out, terracing also checks the erosion of soil by reducing the accelerated velocity of the run-off. Moreover, water may be easily conserved in terraces by making suitable *bunds* for the cultivation of a crop like paddy. This practice is prevalent among two Naga tribes (Ao and Angami) for ages and is already being demonstrated among other Naga tribes and in the North Cachar Hills by the Department of Agriculture, Assam. The people in the Khasi Hills seem to realize the benefits of this method. In fact, irrigation of any crop, grown on terraces would be much easier than that of a crop, growing on hill slopes,

not laid out into terraces. A number of crops can be cultivated in the hills in dry terraces (that is, without irrigation), of which mention may be made of potato, sweet potato, arum, *til* or gingelly, up-land or early paddy, maize, millets and fruits like orange, pine-apple, banana and papaya (fig. 60). Deciduous fruits (apple, peach, plum, pear, apricot, persimmon, nectarine, etc.) can be grown in terraces, round about Darjeeling, Shillong and other hill stations with advantage.

FIG. 60. Terrace system of cultivation of pineapples at Nayabangla near Shillong. (Photo by R. C. Woodford).

Although terraced cultivation would be the ideal in the hills, it is not likely to be achieved easily among the hill people. An alternative would be to modify the practice of *jhuming* so as to reduce its evil effects on the land to a minimum. In this connection, making *bunds* or planting quick-growing shrubs along contour lines is very helpful. This will catch eroded soil and gradually convert *jhums* into terraces. While clearing land for the purpose of *jhuming,* it would be advisable to leave standing trees at intervals in a contour line and also to sow or plant seeds, seedlings or cuttings of some quick-growing trees or shrubs along with the crop. This will provide the *jhum* land quickly with a plant-cover which will check erosion and recuperate the land for future cultivation. The same should be done in abandoned *jhum* lands. In the Khasi Hills and Darjeeling seeds of the pine tree can be sown to advantage in areas where the tree grows, while in other places suitable trees and shrubs may be tried.

2. *Afforestation of the already bare hilly tracts*—At present there are large denuded areas in certain hilly tracts of Assam and

Bengal. The vital interest of the population in land demands that steps should be taken for the afforestation of these areas. The people inhabiting the hills should realize the necessity of taking active interest in this and vigorous propaganda should be carried out to achieve this aim. For the purpose of afforestation, quick-growing trees and grasses with spreading root systems should be grown. The following are suggested :—

Trees : Alder, *mandar* or *palita mander, dumar, babul,* mulberry, *ghora neem, sajna, simul, Kanchan, amra, som, sualu, haritaki, bahera, pouwa* (cedrela toona), etc.

Grasses : *Ikar, khag, borota* (Saccharum nerenga), *kush* (Saccharum spontanuem), *nal, ulu* (Imperata arundinacea), etc.

In denuded hilly land, gullies quickly appear and each new gully is a precursor of heavy future erosion along its line. Planting quick-growing trees and shrubs and putting *bunds* right across in the initial stage are the only practical methods by which the formation of gullies can be checked. Small gullies in the plains near river banks and *khals* should also be checked in the same way.

3. *Control of unrestricted grazing*—Unrestricted grazing has bad effects, similar to that of deforestation. It hinders the growth of vegetation. Moreover, constant trampling of land by cattle in the rainy season leads to heavy erosion. The best alternative would be to grow grasses under cultivation and stall feed the cattle by cut-grasses. If this is not found possible, at least selected areas can certainly be set aside for the purpose of grazing and used in rotation.

4. *Control of fire*—Fire is one of the causes of destruction of forests and grass lands, inducing more erosion. So long as the practice of burning jungle and grasslands for making *jhums* prevails in the hills, fire will continue to do much havoc. It is, however, the duty of every one who makes a *jhum* to see that fire does not spread over land, not required for *jhuming*. Moreover, burning of grass destroys the seedlings of trees and so prevents the recovery of the forest growth which is required to save and enrich the soil.

QUESTION :

1. What do you understand by erosion of soil and conservation of soil ?
2. Where do you find the affect of erosion of soil the most ? Where is it the least ?

3. Why deforestation or indiscriminate cutting of jungles or grassland is harmful ?
4. How does deforestation cause flood ?
5. What steps should be taken to conserve soil in the cultivated areas of the plains and the hills ?
6. What causes sand-deposits in the river bottom of the delta tracts ? What are the evil affects of *chars* in the rivers in the plains ?
7. What should we do to control floods ?

LABORATORY EXERCISES :

1. Note the washing away of the soil in our homesteads by heavy showers.
2. Note the same in the river banks as well as in the hills, if possible.

APPENDIX I

THE SCHOOL GARDEN

Children naturally like to see flowers, fruits and trees which attract them most. It is really a pity to see that a majority of our school houses, either in towns or in distant villages have no ornamental or economic plantation of trees, shrubs and flower plants. The school authorities, especially the local authorities, may easily encourage the students in this side of asthetic culture. If the school compound is beautified on nature's plan, it will be much more attractive and instructive to our boys and girls who will be eager to go there and enjoy themselves.

In building a school house, the secretary of the school may plan the work on the line of landscape architecture and then start it with the help of the teacher. The work should begin in January, when the harvesting is over and the people find enough leisure to help in such a work. The boys and their guardians will surely help in such a wholesome and pleasant move. It is not necessary to do everything in the first year. The work can be carried on year after year, if planned out properly at the outset.

Plan of a school house—Many of our village schools are situated in a small compound, not more than a bigha of land (one-third of an acre approximately). Most of them are either bare or have scattered trees here and there which give a gloomy appearance to the whole compound. If the Head of the school properly plans the work, he can make the school compound a beautiful place in the whole village.

The school house should be built on a suitable site of the school compound so that there may be enough space all round for a play-ground, a garden and a tank or a well. The path from the main gate should be bordered with flower plants up to the front steps with shrubs at the corners and trees, lined up by the compound border. A few vines may be planted at the gate on a bamboo support and at the door steps of the school house.

There should be at least two window boxes with some flower plants. These may be easily made of kerosene-tin boxes. There should be borders in the main path, leading to the school house, covered with various season flowers and lilies. Moreover, the compound fencing may be lined up with *duranta* which will make it very attractive.

The out-houses should be hidden by trees and shrubs. For this a few fruit trees such as mango, litchi, cocoanuts and a few flowering trees such as Bauhinia (Kanchan), Tulip (Parul), Magnolia (Champa) Jasmine, hibiscus etc. will suit best. There should also be some shady spots under the trees for resting at noon and at leisure hours. If there be a tank in the compound, attempt should be made to make a path alongside this tank with borders of season flowers and coco-palms at 30 feet apart.

The teacher should make a plan for gardening for each boy separately and then see that he carries out the work, as directed. A set of garden tools, consisting of *kodali, dao,* rake, pruning knife, fork etc. are needed. Guardians may be asked to help in buying the equipment, if the school cannot afford to get them for the use

of the boys. In our village schools a co-operative effort of the guardians is earnestly sought, especially for flower and vegetable gardening. Moreover, every boy should feel the dignity of labour and he should be asked to co-operate with the other boys to make his own school house a beauty spot in the village.

A good lawn may be made by hoeing the empty spaces in front by a kodali and then after pulverizing the soil and clearing out the weeds, grasses, preferably *Dhub* or *Durba* may be grown. If the weather is dry, water should be sprinkled every evening until the new growth comes up.

Children, taught in this way, will get a start in beautifying their own home. Every guardian should realize the utility of this wholesome training to their children in our village schools and help the school to start the work in right earnest.

The school garden—Every school house should have a garden where the school boys may be allowed to grow vegetables and flowers, as have been prescribed in the laboratory exercises. For this purpose, a piece of land should be acquired and after necessary preparation, it should be alloted to the students in small plots, say 10 feet × 10 feet. Each student should take care of his own plot and grow the crops, as laid down in the laboratory exercises under the guidance of his teacher (Fig. 51). The work should be arranged ahead in such a way that there

FIG. 51

Students working in their individual plots in the Agricultural School, Lyallpur.

may not be any duplication of the same crop. This will give the students a chance to know the crops.

What to plant—In the school garden, an attempt should be made by the teacher to grow both flowers and vegetables and, if possible, it should be continued throughout the year. However, so far as our climatic condition is concerned, the work can easily be carried on continuously provided the teacher can plan it out ahead and collect the materials required. The following is a sample programme for school gradening both in summer and winter which may be tried to advantage.

1. Vegetable Gardening

The work should begin as soon as the rains are over in October. Seeds of cabbage, cauliflower, turnips and knol-kohl should be collected before. The work should proceed as follows:—

1. Make seed boxes with used kerosine-tin boxes.
2. Sow the seeds in the boxes carefully.
3. Prepare the land, manure it well and then lay out individual plots for each student.

4. Sow onions, french beans in rows in somewhat raised beds.
5. Transplant cabbage and cauliflower seedlings temporarily in a line in the laid out plots at 6 inches apart, when they are 2 inches high.
6. Make individual holes for cabbages and cauliflowers at 1½ feet apart and fill them up with cowdung and earth.
7. Re-transplant the seedlings of cabbage and cauliflower when they are about 6 inches high. (Knol-kohl and turnips are transplanted directly from the seed boxes).

It may be mentioned here that the students may grow a line of each vegetable in their individual plots, so that there may be a competition among them.

2. Flower Gardening

As the annuals are numerous, it is not possible to put forward a programme for same. The teacher should find out the suitability of growing flowers and try his best to organize the work accordingly. However, the following may be suggested under two heads:—

a. Annuals.

1. *Summer season*—Make a seed bed and sow zinnea, sunnyflower, aster, vinca, balsum etc. and transplant the same in their proper places, as need be. They may be grown in individual flower beds or in bordering a path.
2. *Winter season*—Try in the same way the following annuals:—Sweet William, cosmos, poppy, *genda*, anterhinum, sweet pea, phlox, petunia etc.

b. Perennials.

1. Cuttings of croton, coleus, hibiscus etc. are to be tried, as opportunity arises.
2. *Roots and bulbs*—Lily bulbs, canna and iris clumps may be put at the corners in individual beds, as desired.
3. *Twiners*—A few twiners, such as the cypress vine (*kunjalata*), passion vine (*jhumka*) and clitoria (*aparajita*) may be planted at the gate.

As for the first preparation of the land, the teacher should get the help of the guardians of the boys. An appeal should also be made to them to contribute towards the buying of a few *kodalis*, and *daos* which will be necessary to do the work in the field. If possible, the school should buy a few sets of gardening implements, such as the hand-hoe, hand-weeding implement, bill-hook etc. The work in the field should be attended to at least thrice during the week. Each plot should be labelled with the names of the crop and the boy who grows it.

Towards the harvesting period the school authorities may organize a show and exhibit the produce of the boys there. The guardians should be invited so that they may have a chance to see the work of their boys and encourage them. Prizes may be awarded for the best produce, if there be any fund at disposal. The produce may be sold to the interested public.

APPENDIX II

A PROPOSED COURSE OF STUDY FOR STUDENTS OF MIDDLE VERNACULAR AND MIDDLE ENGLISH SCHOOLS

(Gardening)

First Year (Class III).

Materials :—

a. Garden tools (hand-hoe, bill-hook, watering can, trowels etc.)
b. Vegetable and flower seeds.
c. A plot of land (10 feet × 10 feet) for each student.

Oral :—

a. Plants: their nature, form and habitat.
b. Relation of plants to animals.

Practical :—

(Winter season)

a. Making a seed bed (vegetable or flower).
b. Cultivation of vegetables or flowers with special attention to the preparation of land, watering, hoeing, weeding etc.

Second Year (Class IV).

Materials :—

a. Garden tools.
b. Seed boxes and flower pots.
c. Vegetable and flower seeds, onion bulbs and potato tubers.
d. A plot of land (10 feet × 10 feet) for each student.

Oral :—

a. Soil and how to prepare it.
b. Use of seed boxes and flower pots.
c. Food grains of every day use.
d. Methods of cultivation of our common vegetables at home.
e. Soil and climate of the locality and crops grown.
f. Decorative plants.
g. Making seed beds, sowing seeds and transplanting.

Practical :—

(Winter season)

a. Preparing flower pots for decorative purposes.
b. Growing a plot of vegetables (onion, cabbage, knol-kohl, turnip, red pepper etc. or flowers like Dahlias, Lily or sunnyflower).

Third Year (Class V).

Materials :—

a. Garden tools.
b. Vegetable and flower seeds.
c. A plot of land (10 feet × 10 feet) for each boy.

Oral :—

a. Life history of various vegetables and flowers (annuals, biennials and perennials).
b. Propagation of plants by seed, cutting, layering, bulbs and tubers.
c. How plants grow.
d. Life history of insects (mosquito, fly, caterpillar, cock-roach, bed-bug, head-louse etc.)

Practical :—

(Winter season)

a. Propagation of plants from cutting (genda), bulbs (onion), tubers (potato) etc.
b. Collection of vegetable and flower seeds and their preservation in phials.
c. Care of the plots of vegetables or flowers.

Fourth Year (Class VI).

Materials :—

1. Simple agricultural and biological books
2. Earthen plates for seed-testing.
3. Sample of different kinds of soils.
4. Hand lens.
5. A plot of land (10 feet × 10 feet) for each student.

Oral :—

a. Origin of soils and their nature.
b. Plant foods in the soil.
functions.
c. Parts of a plant (Root, stem, leaf, flower, fruit and seed) and their
d. Germination of seeds.
e. Relation of water to plants.
f. Relation of water to the soil.
g. Insects and fungus diseases and their control.

Practical :—

a. Seed-testing and the preservation of seeds.
b. Collecting different kinds of soils (Clay, loam and sand).
c. Collection of insects and their preservation.
d. Rearing caterpillars in jars.
e. Transplanting seedlings and cuttings.
f. Growing a plot of flower or vegetable.

B. A PROPOSED COURSE OF STUDY FOR HIGH ENGLISH SCHOOLS OR TRAINING OF TEACHERS FOR MIDDLE VERNACULAR OR MIDDLE ENGLISH SCHOOLS.

(Combined gardening and farming).

First year (Class VII).

Materials :—

a. Seeds of vegetables, flower plants, grasses, field crops and legumes.
b. Garden tools (hand hoe, bill-hook, rake, watering can, trowel and a planet Junior hand hoe).
c. Laboratory equipment, (earthen kalsis, earthen plates, lamp chimneys, measuring rods etc.).

Oral :—

1. Agricultural botany.
   a. Plant life in general.
   b. Short life-history of paddy, wheat, jute, sugarcane, barley etc.
   c. Legumes and their value.
   d. Grasses and their value.
   e. Weeds.
   f. Seeds and seed-testing.

2. Agricultural geology.
   a. Soils : their origin and formation.
   b. Classification of soils ; testing of soils.
   c. Relation of the soil to water.
   d. Chemical constituents of the soil and plant foods.
   e. Relation of plants to the soil.

Practical :—

a. Seed-testing, seed-sowing and transplanting.
b. Water-holding capacity of soils.
c. Different methods of watering plants.
d. Making a flower garden.
e. Collection and preservation of seeds (grains, vegetables, flowers and weeds).
f. Growing plants for decorative purposes.

Second year (Class VIII).

Materials :—

a. Agricultural implements (plough, harrow, ladder etc.)
b. Manure (cowdung).
c. Laboratory equipments (flower pots, sample of manures and fertilizers, secateur, budding knife etc.).

Oral :—

1. Horticulture.
   a. Principles of gardening (fruits and vegetables).
   b. Propagation of plants (budding, grafting, layering etc).

c. Common name and if possible, botanical name of local plants and trees.
d. Method of planting trees.
e. Need of pruning trees.
f. Use of manures and fertilizers.
g. Truck farming.

2. Farming.

a. General principles of farming.
b. Farm crops and how to grow them.
c. Consolidation of holdings and farm fencing.
d. Farm labour.

Practical :—

a. Application of manures in cabbages, peas and beans.
b. Potting plants for decorative purposes.
c. Preservation of cowdung.
d. Pruning orange and rose trees.
e. Propagation of plants by budding, grafting and layering.
f. Attending ordinary farm work.

3rd Year (Class IX).

Materials :—

a. Agricultural implements and a spray pump.
b. Laboratory equipment (milk-testing apparatus, cream separator, egg-incubator, spraying materials etc.)
c. A 3-acre school farm.

Oral :—

1. Agricultural zoology :

a. Animal life in general.
b. Domestic animals and their utility (buffaloes, cows, sheep, goat and hog).
c. Methods of making butter, cheese, ghee and curd.
d. Feeds and feeding.
e. Milk and meat : their chemical constituents and food value.
f. Poultry (fowls, pigeons, ducks and geese).
g. Life history of insects and their control.
h. Housing cattle and poultry.
i. Cattle and poultry diseases and their control.

2. Farming :

a. Crop regions of Assam and their relation to rainfall and temperature.
b. Kharif and rabi crops and how to grow them.

Practical :—

a. Use of a cream separator and making butter.
b. Use of an incubator for hatching eggs.
c. Growing paddy or jute in the school farm (in the summer).

d. Growing mustard, pulses or vegetables in the school farm (in the winter).
e. Collection and preservation of insects.
f. Rearing mosquito larvæ and caterpillars.
g. Spraying kerosene in a pool or stagnant water to kill mosquito wrigglers.

Fourth year (Class X).

Materials:—

a. Agricultural implements.
b. A pump for irrigation.
c. Packing boxes and baskets for fruits and vegetables.

Oral:—

a. Agricultural implements and how to use them.
b. Seasonal crops and how to grow them.
c. Selection of seeds.
d. Care of crops (paddy, jute, sugarcane, vegetables etc.).
e. Control of insect pests and fungus diseases.
f. Harvesting and marketing.
g. Care of cattle, (buffaloes, cows, sheep, goat and hog).
h. Judging cattle.
i. Rotation of crops.
j. Irrigation and drainage.
k. Farm management.
l. Farm accounting.

Practical:—

a. Attending general work in the farm.
b. Use of an irrigation pump.
c. Harvesting crops and packing for sale.
d. Attending local exhibitions.

NOTE:—

The 4-year course in agriculture has been arranged in such a way that the students may take it as an elective or as a major course of study in addition to the other subject in the curriculum of the High English Schools.

The purpose of combining gardening and farming operations is mainly to offer the courses in such a way that the boys may get a link in their work when they come out of the Middle vernacular or Middle English School to get a further training in the High English Schools. Moreover, on the completion of a 4-year course in the H. E. School, the students will be well equipped to teach in the M. V. or M. E. Schools.

APPENDIX III

SOME MAXIMS FOR AGRICULTURE AND AGRICULTURISTS

(A)

1. Purchase small power-serving machinery for the better preparation of your land.

2. As far as practicable, plough the land after the harvest.

3. Drain off surplus water from your fields.

4. Do not cut down your neighbouring forests indiscriminately.

5. Check the erosion of the soil and loss of fertility.

6. Neutralise the acidity or the alkalinity in the soils of your fields.

7. Lime the soils to neutralise acidity and kill the spores of fungi and eggs of insects.

8. Manure your land with a suitable basal dressing of organic manure.

9. Prepare artificial manures by composting the refuses of your fields and homestead.

10. Prepare the land thoroughly before sowing or transplanting.

11. Purchase or raise good seeds and fruit grafts.

12. Raise seeds from the healthiest plants in your fields.

13. Treat your seeds with specific fungicides and sow selected healthy seeds.

14. Select healthy setts for your sugarcane field and treat them with some antiseptic solution before planting.

15. Sow seeds or transplant seedlings as early as possible.

16. Transplant your English vegetable seedlings two times before the final transplantion.

17. Irrigate your crops, whenever necessary.

18. Weed your fields carefully. Give the first weeding very thoroughly and justify the proverbial expression "A stitch in time saves nine".

19. Keep your fields scrupulously clean of wild vegetation. Do not allow weeds to grow even on the border of the fields.

20. Trash the sugarcane field to control the incidence of some insects and diseases.

21. Give intercultures to your crops, specially fruits, vegetables and other money crops.

22. Give top dressing of commercial fertilisers to all money crops.

23. Take control measures at the very incidence of insects and fungi. As a preventive measure against some of the fungus diseases, give a spray of Bordeaux

mixture as soon as your vegetable crop gets a stand and continue spraying at the interval of a month.

24. Try to secure the earliest market for your vegetables.

25. Do not unload your staple harvest in a glutted market. Preserve it for profitable disposal.

26. Do not sell your standing crops at a reduced price.

(B)

1. Maintain animals of good breeds and breed good animals.

2. Feed your animals properly. Grow fodder and concentrates for them. Give them some green feeds all-throughout the year. For this purpose, make silage for the dry period of the year.

3. Graze your animals in the pasture, divided into blocks and supply them with some cut straw with salt after they retire home in the evening from the grazing field.

4. Give the animals sufficient clean water to drink.

5. Take special care of diseased and pregnant animals.

6. Segregate the animals, suffering from infectious diseases from the healthy herd. Carefully dispose of the ramnants of their feeds, dung and urine.

7. Bury down the carcases of animals, died of infectious diseases.

8. Get your cattle inoculated against rinderpest and other infectious diseases.

9. Burn the fallen hair and crusts of animals, attacked by external parasites, such as ticks, lice etc.

10. Wash these animals with Phenyle solution (1 in 100).

11. Feed your calves properly. Try the hand-feeding of the calves and give them sufficient milk during the 1st month of their birth.

12. Examine the dung of your calves every now and then and find out whether they are suffering from the attack of intestinal worms. Treat them, if found attacked.

13. Give every calf a dose of turpentine and linseed oil at an interval, recommended by a Veterinary Surgeon.

14. White wash your cattle-shed 2 or 3 times a year. Burn or disinfect its surface soils off and on and keep the floor dry.

15. Keep your cattle-shed scrupulously clean.

(C)

1. Subsidise your income from land by subsidiary occupations.

2. Rear ship, goats and poultry. Take care of them properly.

3. Grow some money crops, such as fruits, vegetables, sugarcane, potato, tobacco etc.

4. Employ yourself in some spare time employment during the slack season when you are forced to remain idle.

5. Educate your children in the village school or *Pathsala* and co-operate with your neighbours to improve the standard of your occupations and increase the amenities of your life.

6. Avoid unnecessary wastage in social and religious ceremonies.

7. Do not borrow indiscriminately.

8. Improve the sanitation and the communication of your village.

9. Take care of your health. Follow the rules, laid down for the preservation of health.

10. Always drink clean and boiled water.

11. Do not eat stale food.

12. Get yourself and the members of your family and village vaccinated against contagious diseases, whenever they occur in your neighbourhood.

13. Nurse the patients, suffering from contagious diseases with proper precautions.

14. Consult a doctor, whenever you fall ill.

15. Follow these maxims, you will be healthy, wealthy and gay.

APPENDIX IV

INSECTICIDES AND FUNGICIDES

A. Insecticides

1. Kerosene oil emulsion.—

Soap	..	..	.. ½ lb.
Hot water	..	..	.. 1 gallon.
Kerosene	..	..	.. 2 gallons.

Dissolve the soap in hot water and then add the kerosene. Mix the two thoroughly by a home-made bamboo churn or by turning the nozzle of the sprayer back into the mixture again and again. Preserve this stock solution for future use.

For the control of plant lice, cottony cushion scales and woolly aphis, dilute the stock solution with 10 parts of water before use.

2. Crude oil emulsion (see the Chapter on insect pest). To be used for insects mentioned in No. 1.

3. Soap emulsion.—

Soap.	..	..	.. 1 lb.
Water	..	..	.. 1 gallon.

Hot water will dissolve the soap well. This may be used by a hand sprayer for checking the plant lice and other sucking insects in roses or vegetables.

4. Nicotine soap solution.—

Tobacco	..	..	.. 2 lbs.
Water	..	.	.. 2 gallons.

Soak tobacco in hot water for 24 hours or boil for half-an-hour and dissolve ½ lb. soft soap in the mixture to make the stock solution. Dilute with 7-10 gallons of cold water for spraying against aphis, scale and other sucking insects.

5. Lime sulphur.—

Quick lime	..	..	.. 1 lb.
Sulphur	..	..	.. 2 lbs.
Water	..	..	.. 5 gallons.

Bring the water to boil in a big caldron and add first finely powdered sulphur to it slowly and then lime and boil for about half-an-hour. Keep the mixture stirred frequently with a wooden ladle. Strain through a thin markin cloth and dilute to make 5 gallons. For scales and other sucking insects, it may be applied best in winter.

6. Powdered sulphur.—

Dry and powdered sulphur controls the red spiders and mites in orange and litchi trees respectively. A hand blower will do the work satisfactorily. It may preferably be used in the morning when the leaves are still moist with dew.

It will control also the powdery mildew in roses.

7. Lead acetate or Lead arsenate.—

a. Home-made:

Lead acetate	.. ..	½ oz.
Potassium bichromate	..	½ oz.
Water	.. ..	4 gallons.

Mix lead acetate or lead arsenate and Potassium bichromate with water separately in two vessels. Put into a sprayer and fill the same with water. The mixture may preferably be put in a kerosene tin and sprayed with a hand pump after continuous agitation to control moths and other defoliating insects.

b. Lead chromate paste.:

Paste	.. ..	1 lb.
Water	.. ..	30-40 gallons.
	(or)	
Paste	.. ..	1 oz.
Water	.. ..	1 kerosene tinful (roughly)

Mix the paste with water and spray for caterpillars, cock-chafers and other defoliating insects.

8. Poisoned bait.—

Rice bran	1 lb.
Paris green or White arsenic (powder)	1 tea spoonful.
Molasses	2 table spoonfuls.

For cut worms in potatoes and onions, distribute a handful in lines. For grasshoppers and armyworm caterpillars in paddy fields, broadcast it on the *ails* of the field. The bait should be made carefully and kept away from children and dogs.

99. Andres-Maire Trap.—

For cut-worms, surface caterpillars and armyworm caterpillars, Andres-Maire Trap has been devised by the Pusa Institute. The bait of fermented molasses, put in it, entraps the insects in a cage, fixed in the field and thereby prevents egg-laying and subsequent broods of destructive caterpillars. In a kitchen garden the caterpillars should be picked up by hand.

10. Phenyle or kerosenized water.—

Ordinary phenyle or kerosenized water may be used to drive away the red and white ants and crickets. The latter damage the root crop very badly. Mole crickets may be killed by flooding their individual holes.

11. Banding.—

a. *Cotton bands*—A strip of cotton about 4 inches wide, tied around the tree trunk at about 3 feet from the ground will prevent the beetles from climbing up the orange and jackfruit trees. The trunk of the tree, below the band, should be white washed with lime.

b. *Tar*—A strip, about six inches wide, painted up to 3 feet of the base of the tree will prevent the borers from crawling up the trees.

12. Carbon bisulphide.—

10 oz. per 1,000 lbs. of grain.
1 to 1½ lb. per ton of grain.
1 dram (tea-spoonful) per cubic foot of space.
1 oz. per 15 cubic feet of space.

This is used in controlling the stored grain pests. Place the liquid in a shallow vessel above the material to be treated. It is highly inflammable and poisonous, so it should be kept away from lights and never be smelled. For underground insects, rodents and snakes, a few drops may be put in a hole and then covered with dirt.

13. Crude oil or kerosene.—

Spraying crude oil or kerosene over a pool of water will kill the mosquito larvæ. It should be used on a large scale to make a campaign against malaria.

14. Pyrethrum or Flea powder.—

When spread over the floor and bed-steads, it controls the fleas, bed bugs and other household insects.

15. Formalin solution.—

A 3%–5% Formalin (*45% formalin*) solution. sweetened with sugar and placed in a shallow dish will attract and kill flies.

B. Fungicides

1. Bordeaux mixture.—

Copper sulphate (Blue stone)	..	5 lbs.
Quick lime	..	5 lbs.
Water	..	50 gallons.

Dissolve copper salphate in a wooden barrel by hanging it in water in a piece of hessian cloth overnight. Slake the lime in another wooden vessel by adding water gradually until bubbling ceases, after which pour in the rest of water. Then mix the two solutions in a third wooden barrel. Strain the lime solution before it is mixed. The mixture should be alkaline and may be tested by red litmus paper which will be turned blue. The excess of copper can easily be tested by dipping a sharp knife, on which a deposit of copper will form, if the solution is acidic. In that case, more lime should be added to make the solution alkaline.

The application of this solution will control all kinds of fungus and bacterial diseases, such as the early blight (Phytophthora) in potatoes and Fusarium wilt and rot in tomatoes and potatoes in the field.

2. Burgundy mixture.—

Copper sulphate	..	5 lbs.
Washing soda	..	6¼ lbs.
Water	..	50 gallons.

This is to be made in the same way as Bordeaux mixture, using soda instead of lime and may be used in place of Bordeaux mixture.

3. Lime sulphur.—

This is prepared in the same way as No. 5 under insecticides. It may be used for mildews in vines and roses.

4. Powdered sulphur.—

This is to be used in the same way as No. 6 under insecticides. It is also useful for mildews. This is to be applied by a blower.

5. Formalin.—

A 3% Formalin solution may be used to save potatoes from storage rot and wheat from smut. In the case of potatoes, the tubers should be dipped in the solution for half-an-hour, after which they are to be dried and stored.

For wheat, the grains should be dipped in the solution for about 2 hours. Then they are dried overnight and sown in the field. The same solution can be used ten times without losing its strength.

6. Mercuric chloride.—

Mercuric chloride	..	.. 2 oz.
Water	.. ..	.. 20 gallons.

This may be used for the same purpose as formalin, but it does not require more than two hours' dip. The same solution should not be used more than 3 times. No metallic vessel should be used to keep the solution. Moreover, this solution should not be used on vegetables or fruits.

APPENDIX

FRUIT

Name of fruits.	Soil, best suited.	Means of propagation.	Time of trans-planting.	Distance of planting.
(1) Bael (Aegle marmelos)	Deep sandy loam	Seed and root cutting	April–May	20′ × 20′
(2) Pineapple (Ananas sativa)	Well-drained sandy loam	Sucker	Aug.–Sept.	6′ × 3′
(3) Custard apple (Anona squamosa)	Dry well-drained loam	Seed and grafts	April–May	10′ × 10′
(4) Bullock's heart (Anona reticulata)	–Do–	Seed	–Do–	–Do–
(5) Jack-fruit (Artocarpus integrifolia)	Moist sandy to clay loam	Seed	May–June	25′ × 25′
(6) Kamranga (Averrhoa carambola)	Well-drained clay loam	Seed layer	Mar.–April	15′ × 15′
(7) Sapota (Achras sapota)	Moist well-drained loam	Seed, graft and layer	Jan.–Mar.	–Do–
(8) Papaya (Carica papaya)	Well-drained loam	Seed	May–June	10′ × 10
(9) Orange (Citrus aurantium)	Well-drained calcareous loam	Seed and budding	June–July	15′ × 15′

V

CALENDAR.

No. of trees per acre	Time of flowering.	Time of harvesting.	Prominent insect pests	Remedy.	Remarks.
108	June–July	Mar.–April	..	..	Rarely found to grow in the hills.
2,420	Feb.–Mar. June–July	June–Aug. (1st crop) Nov.–Dec. (2nd crop)	..	..	
435	Mar.–April	Aug.–Sept.	..	..	Not grown in the hills.
435	Jan.–Feb.	May–June	..	..	Found to grow almost everywhere in the plains.
70	Feb.–Mar.	June–July	Borers	White-washing the base	
302	May–June Sept.–Oct.	Sept.–Oct. (1st crop) Jan.–Feb. (2nd crop)	..	..	Found to grow in gardens.
193	Feb.–May	June–July	..	..	Found to grow in gardens.
435	No particular flowering season	No particular harvesting season	..	..	Grown in the hills and the plains.
193	Feb.–Mar.	Nov.–Jan.	Borers Lemon tree cater-pillars Die-back and yellowing of leaves	White-washing the base Hand-picking Improved cultural practices	Successfully grown in the hills and also in some localities in the plains.

Fruit

Name of fruits.	Soil, best suited	Means of propagation	Time of transplanting	Distance of planting
(10) Lime (Citrus aurantifolia)	Well-drained calcareous loam	Seed and budding	June–July	15′ × 15′
(11) Lemon (Citrus medica)	–Do–	–Do–	–Do–	–Do–
(12) Pomelo (Citrus decumena)	–Do–	–Do–	–Do–	–Do–
(13) Spanish chestnut (Castenea vesca)	High well-drained loam	Seed and graft	Feb.–Mar.	20′ × 20′
(14) Cocoanut (Cocos nucifera)	Moist calcareous sandy loam	Seed	Mar.–April	25′ × 25′
(15) Bilati Gab (Diospyros khaki)	Deep friable clay loam	Seed and graft	Mar.–April	15′ × 15′
(16) Loquat (Eriobotrya japonica)	Moist deep loam	–Do–	Dec.–Jan.	20′ × 20′
(17) Black Plum (Eugenia jambolana)	Moist loam	Seed and layer	May–June	25′ × 25′
(18) Rose apple (Eugenia jambosa)	–Do–	–Do–	–Do–	15′ × 15′
(19) White apple (Eugenia maleccensis)	Moist loam	–Do–	May–June	10′ × 10′
(20) Strawberry (Fagaria vesca)	Well-drained rich loam	Crowns and seeds	Feb.–Mar.	..
(21) Fig (Ficus carica)	Well-drained loam	Cutting and budding	Mar.–April	15′ × 15′
(22) Walnut (Juglans regia)	Higher deep moist rich loam	Seed and graft	Feb.–Mar.	25′ × 25′
(23) Mango (Mangifera indica)	Deep well-drained loam	Seed, inarching and graft	April–May	–Do–

Calendar (*Contd.*)

No. of trees per acre	Time of flowering	Time of harvesting	Prominent insect pests	Remedy	Remarks.
193	Feb.–Mar.	Nov.–Jan.	Lemon tree cater-pillars	Hand-picking	Found to grow scattered almost everywhere.
193	–Do–	–Do–	–Do–	–Do–	–Do–
193	–Do–	–Do–	–Do–	–Do–	–Do–
108	Mar.–April	–Do–	..	..	Grows in the hills.
70	Feb.–Mar.	Dec.–Jan.	Rhinoceros beetle	White-washing the base with a cotton band	Grows only in the plains.
193	April–May	Aug.–Sept.	..	..	Found to grow in the gardens.
108	–Do–	July–Aug.	..	..	Found to grow in the gardens.
70	March	May	..	..	
193	Feb.–Mar.	May–June	..	..	
435	–Do–	–Do–	..	..	
..	April–May	June–July	..	..	Planted in beds. Suitable for hills only.
193	June–July	Dec.–Jan.	..	..	Suitable in the hills and the plains.
70	Mar.–April	July–Sept.	..	..	Suitable in the hills only.
70	Jan.–Feb.	May–June	Mango-weevil	Clean culture and white-washing the base	Grows almost in every place.

Name of fruits	Soil, best suited	Means of propagation	Time of transplanting	Distance of planting
(24) Banana (Musa spp.)	Well-drained moist rich loam	Suckers	Mar.–April	12′ × 12′
(25) Litchi (Nephalium litchi)	Well-drained loam	Layer and graft	Mar.–April	25′ × 25′
(26) Almond (Prunus amygdalus)	High light loam	Seed and graft	Feb.–Mar.	20′ × 20′
(27) Apple (Pyrus malus)	High well-drained gravelly loam	Graft and budding	Jan.–Feb.	–Do–
(28) Pear (Pyrus communis)	–Do–	Layer and graft	–Do–	–Do–
(29) Cherry (Prunus cerasus)	Well-drained deep loam	Seed and budding	April–May	15′ × 15′
(30) Apricot (Prunus armeniaca)	Well-drained deep sandy loam	Seed and budding	–Do–	–Do–
(31) Plum (Prunus domestica)	Well-drained loam	Seed and graft	–Do–	12′ × 12′
(32) Peach and Nectarine (Prunus persica)	Well-drained deep sandy loam	Seed and budding	–Do–	15′ × 15′
(33) Guava (Psidium guyava)	Average high land soil	Seed and layer	–Do–	12′ × 12′
(34) Pomegranate (Punica granatus)	Dry deep soil	Seed, cutting and layer	–Do–	10′ × 10′
(35) Date palm (Phoenix sylvestris)	Moist calcareous sandy loam	Seed	Mar.–April	20′ × 20′

No. of trees per acre	Time of flowering	Time of harvesting	Prominent insect pests	Remedy	Remarks.
302	Feb.–Mar.	June–July	Beetles and earth-worms	Hoeing and earthing	Grows almost in every place.
70	–Do–	April–May	Borers leaf curl	White-washing kerosene emulsion spray	Does well in the plains and the low hills.
108	Mar.–April	May–Sept.	..	..	Suitable in the hills.
108	–Do–	Aug.–Sept.	Blight or woolly aphis	Spray with kerosene emulsion	Grown in the hills only.
108	–Do–	–Do–	–Do–	–Do–	–Do–
193	Feb.–Mar.	June–July	..	..	–Do–
193	–Do–	–Do–	..	..	–Do–
302	–Do–	–Do–	..	..	Grown in the hills.
193	–Do–	–Do–	Die-back	Soil aeration by cultivation	
302	May–June	Oct.–Dec.	..	..	Grown both in the hills and the plains.
435	–Do–	Nov.–Dec.	..	..	–Do–
193	Feb.–Mar.	June–July	..	..	Suitable in the plains. Tapped for juice in Dec-Jan. The fruit is not of much use.

Fruit

Name of fruits	Soil, best suited	Means of propagation	Time of transplanting	Distance of planting
(36) Black berry (Rubus fruticosus)	Well-drained loam	Root and cutting	Dec.–Jan.	5′ × 5′
(37) Raspberry (Rubus idaeus)	–Do–	Suckers and seeds	Feb.–Mar.	–Do–
(38) Country plums (Zyzyphus valgaris)	Moist clay loam	Seed and graft	Mar.–April	15′ × 15′

Calendar (*Contd.*)

No. of trees per acre	Time of flowering	Time of harvesting	Prominent insect pests	Remedy	Remarks.
1,960	Feb–Mar.	June-July	..	..	Suitable in the hills.
1,960	-Do-	-Do-	..	..	Grows well in the hills and the plains.
193	Sept.–Oct.	Jan.–Feb.	..	..	Both cultivated and wild in the hills and the plains.

APPENDIX

VEGETABLE

Name of vegetables.		
English.	Indian.	Soil, best suited.
(1) Artichoke, Jerusalem	Hatichuk	Well-drained rich loam
(2) Artichoke, globe	Hatichuk	–do–
(3) Asparagus	Satamuli	–do–
(4) Bean (sword)	Bara shim or uri.	Sandy garden loam
(5) Bean (country)	Shim	–do–
(6) Bean (French or Kidney).	Farash	–do–
(7) Bean (Broad)	Bakla shim	–do–
(8) Bean Asparagus (Barbati)	Lobia	–do–
(9) Beet	Chakunder or Beet palang	Light sandy loam
(10) Borecole or kale	Pata kafee	–do–
(11) Brussels sprouts	Choke kafee	Rich heavy loam
(12) Borecole	Chota phul kafee	Rich heavy loam
(13) Cabbage	Banda kafee	Rich well-drained loam
(14) Cauliflower	Phul kafee	Rich heavy loam

VI

CALENDAR.

Time of sowing.	Distance of transplanting.	Period of growth.	Remarks.
* Feb.–May, June–Octr.	3′–4′	5–6 months	Grown mostly in the hills from tubers.
–do–	–do–	–do–	Perennial.
* Feb.–May, June–Septr.	2′	..	Perennial.
* April–June, August–Octr.	5′–6′	2–4 months	
–do–	–do–	2–3 months	
* April–June, August–Decr.	8″–12″	2 months	
–do–	–do–	–do–	
March–July	4′–5′	–do–	
* Feb.–March, Septr.–Novr.	6″–9″	2–3 months	
–do–	9″–12″	–do–	
* Feb.–March, Septr.–Novr.	2′–2.5′	3–4 months	
* Feb.–April, August–Novr.	2′	–do–	
* Feb.–May, August–Septr.	2′–2.5′	2–3 months	
* Feb.–April, August–Novr.	2′	3–4 months	

* For hills only.

Vegetable

Name of vegetables. English.	Indian.	Soil, best suited.
(15) Cucumber	Sasha	Light rich loam
(16) Cucumber	Khira	-do-
(17) Cress (garden)	Halim	-do-
(18) Cress (water)	-do-	-do-
(19) Capsicum, chillies	Marich	-do-
(20) Carrots	Gajor	Light sandy loam
(21) Celery	Shalari	Light rich loam
(22) Celeriac	-do-	-do-
(23) Egg plant	Begun	-do-
(24) Gourd	Lau	-do-
(25) Gourd (bitter)	Karala	-do-
(26) Gourd (Melon)	Phuti	Silted soil.
(27) Gourd (Snake)	Chichinga	Light loam
(28) Gourd (white)	Chalkumra	-do-
(29) Gooseberry, cape	Tipari	-do-
(30) Garlic	Rasoon	-do-
(31) Khol-rabi	Gandha kafee	Heavy rich loam
(32) Lady's finger	Bhendi or Dheresh	-do-
(33) Lettuce	Salad	Light rich loam

Calendar. (*Contd.*)

Time of sowing.	Distance of transplanting.	Period of growth.	Remarks.
Jan.–March	5′–6′	3 months	
Decr.–February	2′–3′	2 months	
* March–Septr, Septr.–February		1–2 weeks	Sown broadcast
–do–		4 weeks	–do–
–do–	1′–1.5′	3 months	
* Feb.–May, Septr.–Novr.	4″–6″	3 months	
* Feb.–April, May–June	12″–16″	5–6 months	Planted in trenches
–do–	–do–	–do–	
* Feb.–March, August–Septr.	3′–4′	3 months	
–do–	5′–6′	–do–	Sown in Situ.
Octr.–Novr.	4′–5′	3 months	–do–
Feb.–April	5′–6′	–do–	–do–
March–April	5′	–do–	–do–
Feb.–March	–do–	4 months	–do–
April–June	2′	6 months	
* March–May, Octr.–Novr.	6″	4 months	
* Feb.–March, August–Novr.	9″–12″	2–3 months	
* March–June, April–May	2′–3′	3 months	
* Feb.–March, August–Decr.	9″–12″	2–3 months	

* For hills only.

Vegetable

Name of vegetables		
English.	Indian.	Soil, best suited.
(34) Leek	Bilati piaz	Rich sandy loam
(35) Mustard (garden)	Sada Rai	Light loam
(36) Mustard	Sarson	Light rich loam
(37) Melon	Phuti	Light sandy silt
(38) Melon, water	Tarmuz	–do–
(39) Melon Musk	Kharbuz	–do–
(40) Maize	Makkai	Light garden loam
(41) Onion	Piaz	Heavy rich loam
(42) Patal	Patal	Rich garden loam
(43) Pumpkin	Kumra	Light loam
(44) Potato, sweet	Mita alu	Garden loam
(45) Potato	Gol alu	Well-drained sandy loam to clay loam
(46) Parsley	Ajamoda	Heavy rich loam
(47) Parsnip	Sada gajar	–do–
(48) Peas	Matar	Rich garden loam
(49) Radish	Mula	Light rich loam

Calendar. (*Contd.*)

Time of sowing.	Distance of transplanting.	Period of growth	Remarks.
* Feb.–April, Septr.–Novr.	6″-9″	2 months	
* March–Septr., All the year round except June–July		1 month	Sown broadcast Used as *sak*.
* March–May, All the year round		4 weeks	–do–
Octr.–January	4′	3-4 months	
–do–	4′	–do–	
–do–	–do–	8 months	
March–May	12″	–do–	
* March–May, Octr.–Novr.	..	4 months	
August–Septr.	4′-5′	–do–	Root cutting.
* Feb.–June, Feb.–June	–do–	3–4 months	Sown in situ.
July–August	3′	4 months	Both stem and root cutting.
* March–July, * August–Octr., Octr.–Decr.	12′	–do–	
* March–May, Octr.–Novr.		2 months	Sown broadcast
* March–May, Octr.–Novr.		3 months	–do–
* Feb.–May, Octr.–Decr.	3″	1½–2 months	
* March–May, Septr.–January		3–4 weeks	Sown broadcast

* *For hills only.*

Vegetable

Name of vegetables			
	English.	Indian.	Soil, best suited.
(50)	Rape or col	Bara lai	Light rich loam
(51)	Roselle	Chukair	Heavy rich loam
(52)	Spinach	Palang sag	Light rich loam
(53)	Squash	Sada kumra	–do–
(54)	Sorrel	Kata palang	Garden loam
(55)	Tomato	Bilati begun	Light rich loam
(56)	Turnip	Shalgum	–do–
(57)	Yams, country	Mete alu	–do–
Herbs.—			
(58)	Aniseed	Mouri	–do–
(59)	Basil	Gulal tulsi	Garden loam
(60)	Carraway	Jira	–do–
(61)	Coriander	Dhania	Heavy loam
(62)	Dill	Pan mouri	Light rich loam
(63)	Fenugreek	Methi	–do–
(64)	Fennel	Bara mouri	–do–
(65)	Marjoram	Ban Tulsi	–do–
(66)	Mint	Padina	Light sandy loam

Calendar. (*Contd.*)

Time of sowing.	Distance of transplanting.	Period of growth.	Remarks.
* March-May, Septr.-January.	1½″	1 month	
March–May	4′	5 months	
* Feb.–May, Septr.–Novr.		2 months	Sown broadcast.
* March–June, August–Jany.	6′	3 months	
* Feb.–April, Septr.–Novr.		2 months	Sown broadcast.
* March–May, August–Novr.	2′–2.5′	3 months	
* Feb.–May, August–Decr.	6″.9″	–do–	
April–May	4′–5′	8 months	Planted in pits.
* Feb.–May, Octr.–Novr.		3–4 months	Sown broadcast.
–do–		–do–	-do-
* Feb.–May, Septr.–Novr.		-do–	-do-
* Feb.–May, Octr.–Novr.		–do–	-do-
* Feb.–May, August–Novr.		–do–	-do-
* Feb.–May, August–Novr.		3 months	-do-
–do–		–do–	-do-
–do–		–do–	-do-
* Feb.–May, June–July		1 month	Propagated from cuttings

* For hills only.

APPENDIX

FIELD CROP

No.	Crop.	Soil, best suited.	Seed rate per acre.	Time of sowing
Cereals.—	Paddy—			
1 a Aus (Ahu)	(a) Broadcast aus or ahu	Sandy loam to clay	30 srs.	April–May
	(b) Transplanted aus or ahu	–do–	10 srs.	–do–
b. Aman (Amana)	(a) Sail or (Sali)	Clay loam to clay	10 srs.	June–Aug.
	(b) Asra or (Bao)	Clay	10 srs.	–do–
	(c) Aman or Asra (Broadcast)	–do–	30 srs.	Mar.–April
c. Boro	Boro	Silted clay	10 srs.	Oct.–Nov.
2	Wheat	Clay or sandy loam	50 ibs.	Nov.–Dec.
3	Barley	Loam	60 lbs.	–do–
4	Oats	Sandy loam to clay	50 ibs.	–do–
5	Bhutta or (Maize)	High open soil	3–4 srs.	April–May
6	Jowar	–do–	10 lbs. for grain and 20 lbs. for fodder	–do–
7	Marua	–do–	7 lbs. and 10 lbs.	–do–

VII

CALENDAR

Distance of transplanting or sowing	Time of harvesting	Yield per acre in mds.	Remarks.
..	June–July	18–20 mds.	Summer rice (Dumai, Murali and Chengri of Sylhet).
6″ × 6″	July-Aug.	20–22 „	Autumn rice.
9″ × 9″	Nov.–Dec.	25–30 „	Winter rice.
12″ × 12″	–do–	30–25 „	Winter rice (Shallow water aman of Sylhet).
..	–do–	35–40 „	Winter rice (Deep water aman).
12″ × 12″	Mar.–April	35–40 „	Spring rice.
..	Feb.–March	9–10 „	Deep feeder.
..	–do–	12–15 „	Surface feeder.
..	–do–	15–20 „	2–3 cuttings may be taken for fodder and then left for a thin harvest.
18″ each way	Aug.–Sept.	10–12 „	For fodder and grain.
..	–do–	10–12 mds. grain & 280 mds. fodder	May be used for fodder and grain.
„	–do–	8–10 mds. grain & 1000 lbs. straw	

Field Crop

No.	Crop.	Soil, best suited.	Seed rate per acre.	Time of sowing
8	Cheena	High open soil	10 lbs.	Feb. & March or August
9	Shyama	-do-	2 lbs.	May-June
10	Gondli	-do-	10 lbs.	June-July
11	Menjhri or Kutki	-do-	2 lbs.	June
12	Kaon and Shyalnaja	High sandy loam	5 lbs.	Oct.-Nov.
13	Bajra	Rich sandy loam	6-10 lbs.	-do-
14	Kodo	Well-drained loam.	2 lbs.	April
15	Buckwheat	Sandy rich loam	50 lbs.	June-July
Legumes.—				
16	Arhar	Rich clay loam	5-10 lbs.	April-May
17	Gram	Silted loam	25-50 lbs.	Oct.-Nov.
18	Kulthi (Madras gram)	-do-	20-25 lbs.	-do-
19	Popat or Val	-do-	5-8 lbs.	July-Aug.
20	Soybeans (Gari kalai)	Sandy loam	30 lbs	Oct.-Nov.
21	Khesari	Silted loam	12-16 lbs.	
22	Musuri	-do-	12 lbs.	Oct.-Dec.
23	Moth bean	Loam	8 lbs.	June-July

Calendar (*Contd.*)

Distance of transplanting or sowing	Time of harvesting	Yield per acre	Remarks.
..	May or Oct.	600 lbs. of grain & 1000 lbs. of straw	
..	Sept.–Oct.	400 lbs. grain & 800 lbs. of straw	Grown for fodder.
..	Oct.–Nov.	500 lbs. grain & 1000 lbs. straw.	–do–
..	October	600 lbs. grain	
..	Mar.–April	500 lbs. grain & 1000 lbs. straw	
..	Jan.–Feb.	400 lbs. grain & 1000 lbs. straw	
..	August	600 lbs. grain	Grown for gram and fodder.
..	October, Jan. and Feb.	1200 lbs.	Grown in the Khasi hills.
4′ × 4′	Mar.–April	800 lbs.	
	–do–	400 lbs.	
	February	300 lbs. & 5 tons of green fodder	
	Jan.–Feb.	250 lbs. 400 lbs. straw	
	Mar.–April	400–500 lbs.	May be used for fodder; green manuring & seed.
	March ..	300 lbs. & 400 lbs. straw	
	Feb.–March	350 lbs.–750 lbs. & same quantity of straw	
	Sept.–Oct.	–do–	

Field Crop

No.	Crop.	Soil, best suited.	Seed rate per acre.	Time of sowing
24	Urd or Birni or Katkia kalai	Loam	8 lbs.	June
25	Mashkalai or Matikalai	Silted loam	–do–	Sept.–Oct.
26	Mung	Loam	–do–	October
27	French bean	Rich loam	20 lbs.	Oct.–Dec.
28	Country bean	–do–	10–20 lbs. for grain & fodder	Nov.–Dec.
29	English peas	–do–	15 lbs.	–do–
30	Cowpea	Loam to clay	12 lbs.	April–May Oct.–Nov.
31	Cluster bean	Loam	10 lbs.	April–May or Sept.–Oct.
Oilseeds.—				
32	Mustard and sarson	Silted loam	4–6 lbs.	Oct.–Nov.
33	Linseed	Heavy rich land	6–10 srs.	Nov.–Dec.
34	Gingelly or til	Silted loam to clay	5–10 srs.	Aug.–Sept.
35	Sorguja or Niger	Loam	5–10 srs.	–do–
Oilseeds.—				
36	Castor	Rich loam	..	May–July or Oct.–Nov.
37	Ground nut	Loam	20 srs.	Feb.–April & Sept.–Oct.

Calendar (*Contd.*)

Distance of transplanting or sowing	Time of harvesting	Yield per acre	Remarks.
..	September	350–750 lbs. & same quantity of straw	
..	Jan.–Feb.	300 to 600 lbs. grain & 400–800 lbs. of straw	May be used for fodder, seed and green manuring
..	February	200–500 lbs. & same quantity of straw	
..	Dec.–Mar.	1,600–2,000 lbs.	
	Mar.–April	500–1,000 lbs.	Does well with oats for fodder.
..	Feb.–March	1,200–2,000 lbs.	
..	Aug. or March	50 mds. of barbati or 10 mds. dal	Used for fodder & green manuring.
..	Aug. or Feb.	100–200 mds. of green fodder or 40–50 mds. of green legume	
..	Feb.–March	6–10 mds.	Oil seeds.
..	March	6–10 mds.	Yields ¼ of its own weigh of oil and oilcake.
..	Jan.–Feb.	6–10 mds.	
..	–do–	6–10 mds.	Oil.—33% of the weight of seed.
..	Jan.–Feb. & June–July	250 lbs. seed	25–35% of oil. Grown for rearing eri worms.
1 ft. each way	Sept.–Nov. & Mar.–April	30–40 mds.	

Field Crop

No.	Crop.	Soil, best suited.	Seed rate per acre.	Time of sowing
38	Cocoanut	Saline loam	200 trees	..
Fibres.—				
39	Jute	Rich loam	9 lbs.	Feb.-March
40	Sunn hemp	Clay loam	10–12 lbs.	April-May Sept.-Oct.
41	Rhea	Rich loam to clay	Cutting	April-May
42	Cotton	Clay loam	5–10 lbs. seed	–do–
Miscellaneous.—				
43	Potato	Rich loam	8 mds.	Sept.-Oct.
44	Turmeric	Sandy loam	2 mds.	March-April
45	Ginger	–do–	2 mds.	–do–
46	Sugarcane	Rich light loam	Cuttings	–do–
47	Tobacco	Rich high-land loam	½ oz. of seed in seed bed	October
48	Pan	Rich loam	Root cutting	May-June
49	Areca palm	Sandy to clay loam	680 plants	Oct.-Nov. (seeds) April-May (seedlings)
50	Cassava (Simul alu)	Sandy to clay loam	1700 plants	..
51	Yam	Rich loam		April-May
52	Kachu	Sandy loam to clay		April-May
..	Pani kachu	Clay		April-May
..	Mukhi kachu	Clay loam		–do–
..	Man kachu	Sandy loam		During the rains
..	Naga kachu	–do–		April-May
..	Ol kachu	–do–		April-May
53	Safflower	20–25 lbs.		Oct.-Nov.

Calendar. (*Contd.*)

Distance of transplanting or sowing	Time of harvesting	Yield per acre	Remarks.
15′ × 15′	..	Rs. 100|- per acre.	Oil from cobra. Coir, rope & mat from fibre
..	July-Aug.	15 mds.	
..	Aug.-Sept or Jan.-Feb.	200–1,200 lbs. fibre	
2′ × 2′	2 or 3 cuttings may be obtained	7–8 mds.	
4′ × 4′	Feb.-March	100 to 200 lbs. cotton, 300–600 lbs. cotton seed	Cotton seed oil. Cotton seed meal.
6″ × 12″	Feb.-March	100–150 mds.	
9″ × 25″	Dec.-Jan.	16 mds. (dried) 50 mds. (green)	
–do–	–do–		
End to end of cutting	Dec.-March	3,500–8,000 lbs. of gur	
18′ × 2′	Feb.-March	20–24 mds.	
6″ × 2′	October	80 lacs of leaves	
4″ × 6″	Oct.-Nov. &	5–8 mds.	
8′ × 8′	Dec.-Jan.		
5′ × 5′		450 mds. of roots and 210 mds. of green fodder	
	Nov.-Dec.		
	..	..	
	..	..	
	..	..	
	..	..	
	..	..	
	..	..	
	Jan.-Mar.	Flowers 80–100 lbs. seed 400–600 lbs.	Dye and oil.

APPENDIX VIII

1. WEIGHTS AND MEASURES

(1) Metric or French System

1 metre (m.) = 10 decimetres (dm) = 100 centimetres (cm.) = 1,000 millimetres (mm.) = 1.09 yards = 3.281 feet = 39.371 in.

1 litre (l.) = 1,000 cubic centimetres (c. c. or c. cm.) = 0.22 gallon = 1.76 pints = 35.2 fluid oz.

1 cubic metre (cb. m.) = 1,000 litres = 220 gallons.

1 gramme (g. or gr. or grm.) = 10 decigrammes (dg.) = 100 centigrammes (eg.) = 1,000 milligrammes (mg.) = 15.43 grains.

1,000,000 grammes = 1 metric ton; 1,017,960 grammes = 1 ton of 2,240 lbs.

1 kilogramme (kg.) = 1,000 grammes = 35.27 oz. = 2.2 lbs.

50 kilogrammes = 1 centner = 1 cwt. approximately.

100 kilogrammes = 1 quintal or 1 metric centner = 1 deppelzentner or 1 dz. = 1/10th ton approximately.

1,000 kilogrammes = 1 ton (t.) i.e., metric ton = 19 cwt. 77 lbs. = 2,204.6 lbs.

1 cubic centimetre of water = 1 gramme.

1 litre of water = 1 kilogramme = 2.2 lbs. (approximately 1 seer).

1 cubic metre of water = 1 metric ton = 2,204.6 lbs.

(2) English Weights and Measures.

1 yard (yd.) = 3 feet = 91.44 centimetres = 0.9144 metre.

1 foot (′) = 12 inches (″) = 30.48 centimetres = 0.3048 metre.

1 cubic foot = 28.317 litres.

1 inch = 2.54 centimetres; 1 cubic inch = 0.01639 litre.

1 imperial gallon (gal.) = 4 quarts (qts.) = 8 (pints.) = 16 gills = 32 noggins = 10 lbs. (of water) = 4.54 litres (almost equal to 5 seers).

1 pint = 0.568 litre = 2 gills = 4 noggins = 1¼ lbs. (approximately over ½ seer).

1 pound avoirdupois (lb.) = 16 oz. = 256 drams (drm.) = 7,000 grains = 453.6 grams = .454 Kg.

1 oz. = 16 drams = 437.5 grains = 28.35 grams; 1 fluid oz. = 28.4 c.c.

1 hundredweight (cwt.) = 4 quarters (28 lbs. each) = 112 lbs.

1 ton (t.) = 20 cwt. = 2,240 lbs. = 1,016 kilos. = 1.016 metric tons.

1 grain = 0.0648 grams; 7,000 grains = 1 lb. (Avoir).

A barrel contains 36 gallons. A half barrel (18 gallons) is called a Kilderkin and a quarter barrel (9 gallons) a Firkin. A hogshed (hhd.) of ale contains 1½ barrels or 54 gallons; a butt of ale is 3 barrels and a pipe 6 barrels.

(3) Indian Weights and Measures.

4 sikis=1 tola=weight of a rupee=180 grains troy.

5 sikis=1 kancha.

4 kanchas or 5 tolas=1 chhatak.

16 chhataks=1 seer=80 tolas=approximately 2 lbs.

40 seers=1 maund=100 lbs. troy=82 2/7 lbs. Avoir.

35 seers=72 lbs. Avoir.

4 chhataks=1 powa=approximately ¼ lb.

1 lb. Avoir+the weight of a double pice (200 grs.)=¼ seer.

8 Factory maunds=2 Cwt.

49 Bazar maunds=36 Cwt.=54 factory maunds.

1 Cwt.=1 maund 14 seers and 7 1/9 chhataks.

2. TABLE FOR SURFACE MEASURE

Sq. mile	Acre.	Sq. pole or rd.	Sq. yd.	Sq. ft.	Sq. in.
1 =	640 =	102,400 =	3,097,600 =	27,878 400 =	4,014,489.600
	1 =	160 =	4,840 =	43,560 =	6,272,640
		1 =	30¼ =	272¼ =	39,204
			1 =	9=	1,296

APPENDIX IX

Number of Trees per Acre at Various Distances

Planting trees :

To find out the number of trees per acre, divide 43, 560 by the product of two distances in ft., at which the trees are to be planted ; the quotient will be the number of trees required.

Number of Trees per Acre at Various Distances.

	3′	3′6″	4′	4′6″	5′	5′6″	6′
3′	4,840						
3′6″	4,148	3,555					
4′	3,630	3,111	2,722				
4′6″	3,226	2,765	2,419	2,150			
5′	2 904	2,489	2,178	1,936	1,742		
5′6″	2,640	2 263	1,980	1,760	1,584	1,440	
6′	2,420	2,074	1,815	1,613	1,452	1,320	1,210

APPENDIX X

1. Conversion and Comparison of Thermometer Degrees

FORMULÆ :—

$$F^\circ = (C^\circ \times 9/5 + 32)$$

$$C^\circ = (F^\circ - 32.) \times 5/9$$

Comparison of Centigrade and Fahrenheit Degrees.

C.°	F.°	C.°	F.°	C.°	F.°	C.°	F.°
500	932	74	165·2	45	113	16	60 8
400	752	73	163·4	44	111·2	15	59
300	572	72	161·6	43	109·4	14	57 2
200	392	71	159·8	42	107·6	13	55·4
100	212	70	158	41	105·8	12	53·6
99	210·2	69	156·2	40	104	11	51·8
98	208 4	68	154·4	39	102·2	10	50
97	206 6	67	152·6	38	100·4	9	48 2
96	204·8	66	150·8	37	98·6	8	46·4
95	203	65	149	36	96·8	7	44·6
94	201·2	64	147·2	35	95	6	42 8
93	199·4	63	145·4	34	93·2	5	41
92	197 6	62	143·6	33	91 4	4	39·2
91	195 8	61	141·8	32	89 6	3	37·4
90	194	60	140	31	87 8	2	35·6
89	192 2	59	138 2	30	86	1	33·8
88	190·4	58	136·4	29	84 2	0	32
87	188 6	57	134·6	28	82·4	—1	30 2
86	186·8	56	132·8	27	80·6	—2	28·4
85	185	55	131	26	78 8	—3	26·6
84	183 2	54	129·2	25	77	—4	24 8
83	181·4	53	127 4	24	75·2	—5	23
82	179·6	52	125·6	23	73 4	— 6	21·2
81	177·8	51	123·8	22	71·6	— 7	19·4
80	176	50	122	21	69·8	—8	17·6
79	174·2	49	120·2	20	68	—9	15·8
78	172·4	48	118·4	19	66·2	—10	14
77	170·6	47	116·6	18	64·4	—11	12·2
76	168·8	46	114·8	17	62 6	—12	10·4
75	167	...	...	...	...	...	...

APPENDIX XI

CHART FOR CALCULATING RELATIVE HUMIDITY OF AIR.

[Table for finding the Relative Humidity of the Air from the readings of the dry bulb t and wet bulb t′ thermometers at the mean barometric pressure of 29·7 inches.]

Wet Bulb t′	Value of t—t′ in degrees Fahrenheit.												
	0.5	1.0	1.5	2.0	2.5	3 0	3.5	4.0	4.5	5.0	5.5	6.0	6.5
35	95	90	85	81	76	72	68	64	60	56	52	49	45
36	95	90	86	81	77	72	68	64	61	57	53	50	47
37	95	90	86	81	77	73	69	65	62	58	54	51	48
38	95	91	86	82	78	74	70	66	62	59	56	52	49
39	95	91	87	82	78	74	71	67	63	60	56	53	50
40	96	91	87	83	79	75	71	68	64	61	57	54	51
41	96	91	87	83	79	75	72	68	65	62	58	55	52
42	96	91	87	84	80	76	72	69	66	62	59	56	53
43	96	92	88	84	80	77	73	70	66	63	60	57	54
44	96	92	88	84	81	77	74	70	67	64	61	58	55
45	96	92	88	85	81	78	74	71	68	65	62	59	56
46	96	92	89	85	81	78	75	72	68	65	62	60	57
47	96	92	89	85	82	78	75	72	69	66	63	60	58
48	96	93	89	86	82	79	76	73	70	67	64	61	59
49	96	93	89	86	83	79	76	73	70	67	64	61	59
50	96	93	89	86	83	80	77	74	71	68	65	63	60
51	96	93	90	86	83	80	77	74	71	69	66	63	61
52	97	93	90	87	83	80	77	75	72	69	67	64	62
53	97	93	90	87	84	81	78	75	72	70	67	65	62
54	97	93	90	87	84	81	78	75	73	70	68	65	63
55	97	93	90	87	84	81	79	76	73	71	68	66	63
56	97	94	91	88	85	82	79	76	74	71	69	66	64
57	97	94	91	88	85	82	79	77	74	72	69	67	65
58	97	94	91	88	85	82	80	77	75	72	70	67	65
59	97	94	91	88	85	83	80	78	75	73	70	68	66
60	97	94	91	88	86	83	80	78	75	73	71	68	66
61	97	94	91	89	86	83	81	78	76	73	71	69	67
62	97	94	91	89	86	84	81	79	76	74	72	69	67
63	97	94	92	89	86	84	81	79	77	74	72	70	68
64	97	94	92	89	87	84	82	79	77	75	73	70	68

APPENDIX XI

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CHART FOR CALCULATING RELATIVE HUMIDITY OF AIR.

[Table for finding the Relative Humidity of the Air from the readings of the dry bulb t and wet bulb t′ thermometers at the mean barometric pressure of 29.7 inches.]

Wet Bulb. t′	Value of t—t′ in degrees Fahrenheit.												
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5
65	97	94	92	89	87	84	82	80	77	75	73	71	69
66	97	95	92	89	87	85	82	80	78	75	73	71	69
67	97	95	92	90	87	85	82	80	78	76	74	72	70
68	97	95	92	90	87	85	83	80	78	76	74	72	70
69	97	95	92	90	88	85	83	81	79	76	74	72	70
70	97	95	92	90	88	85	83	81	79	77	75	73	71
71	97	95	92	90	88	86	83	81	79	77	75	73	71
72	97	95	93	90	88	86	84	81	79	77	75	73	72
73	98	95	93	90	88	86	84	82	80	78	76	74	72
74	98	95	93	90	88	86	84	82	80	78	76	74	72
75	98	95	93	91	88	86	84	82	80	78	76	74	73
76	98	95	93	91	89	86	84	82	80	78	76	75	73
77	98	95	93	91	89	87	85	83	81	79	77	75	73
78	98	95	93	91	89	87	85	83	81	79	77	75	74
79	98	95	93	91	89	87	85	83	81	79	77	76	74
80	98	95	93	91	89	87	85	83	81	79	78	76	74
81	98	96	93	91	89	87	85	83	81	80	78	76	74
82	98	96	93	91	89	87	85	84	82	80	78	76	75
83	98	96	94	91	89	88	86	84	82	80	78	77	75
84	98	96	94	92	90	88	86	84	82	80	79	77	75
85	98	96	94	92	90	88	86	84	82	80	79	77	75
86	98	96	94	92	90	88	86	84	82	81	79	77	76
87	98	96	94	92	90	88	86	84	83	81	79	78	76
88	98	96	94	92	90	88	86	85	83	81	79	78	76
89	98	96	94	92	90	88	86	85	83	81	80	78	76

APPENDIX XI

(Contd.)

CHART FOR CALCULATING RELATIVE HUMIDITY OF AIR.

[Table for finding the Relative Humidity of the Air from the readings of the dry bulb t and wet bulb t′ thermometers at the mean barometric pressure of 29·7 inches.]

Wet bulb t′	Value of t—t′ in degress Fahrenheit.												
	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
60	64	62	60	58	56	54	52	51	49	47	46	44	42
61	65	63	61	59	57	55	53	51	50	48	46	45	43
62	65	63	61	59	57	56	54	52	50	49	47	46	44
63	66	64	62	60	58	56	54	53	51	49	48	46	45
64	66	64	62	60	59	57	55	53	52	50	49	47	46
65	67	65	63	61	59	57	56	54	52	51	49	48	46
66	67	65	63	62	60	58	56	55	53	51	50	48	47
67	68	66	64	62	60	59	57	55	54	52	51	49	48
68	68	66	64	63	61	59	57	56	54	53	51	50	48
69	68	67	65	63	61	60	58	56	55	53	52	50	49
70	69	67	65	63	62	60	58	57	55	54	52	51	49
71	69	67	66	64	62	61	59	57	56	54	53	51	50
72	70	68	66	64	63	61	59	58	56	55	53	52	51
73	70	68	67	65	63	62	60	58	57	55	54	53	51
74	70	69	67	65	64	62	60	59	57	56	54	53	52
75	71	69	67	66	64	62	61	59	58	56	55	54	52
76	71	69	68	66	64	63	61	60	58	57	55	54	53
77	71	70	68	66	65	63	62	60	59	57	56	55	53
78	72	70	68	67	65	64	62	61	59	58	56	55	54
79	72	70	69	67	66	64	63	61	60	58	57	56	54
80	72	71	69	67	66	64	63	61	60	59	57	56	55
81	73	71	69	68	66	65	63	62	60	59	58	56	55
82	73	71	70	68	67	65	64	62	61	60	58	57	56
83	73	72	70	68	67	65	64	63	61	60	59	57	56
84	74	72	70	69	67	66	64	63	62	60	59	58	56
85	74	72	71	69	68	66	65	63	62	61	59	58	57
86	74	72	71	69	68	66	65	64	62	61	60	58	57
87	74	73	71	70	68	67	65	64	63	61	60	59	58
88	75	73	71	70	69	67	66	64	63	62	60	59	58
89	75	73	72	70	69	67	66	65	63	62	61	60	58

APPENDIX XI

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CHART FOR CALCULATING RELATIVE HUMIDITY OF AIR.

[Table for finding the Relative Humidity of the Air from the readings of the dry bulb t and wet bulb t' thermometers at the mean barometric pressure of 29·7 inches.]

Wet bulb t'	Value of t—t' in degrees Fahrenheit.												
	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5
60	41	39	38	37	35	34	33	31	30	29	28	27	26
61	42	40	39	37	36	35	34	32	31	30	29	28	26
62	43	41	40	38	37	36	34	33	32	31	30	29	27
63	43	42	40	39	38	36	35	34	33	32	31	29	28
64	44	43	41	40	39	37	36	35	34	32	31	30	29
65	45	43	42	41	39	38	37	36	34	33	32	31	30
66	45	44	43	41	40	39	38	36	35	34	33	32	31
67	46	45	43	42	41	40	38	37	36	35	34	33	32
68	47	45	44	43	42	40	39	38	37	36	34	33	32
69	47	46	45	43	42	41	40	39	37	36	35	34	33
70	48	47	45	44	43	42	40	39	38	37	36	35	34
71	49	47	46	45	44	42	41	40	39	38	37	36	35
72	49	48	47	45	44	43	42	41	39	38	37	36	35
73	50	49	47	46	45	44	42	41	40	39	38	37	36
74	50	49	48	47	45	44	43	42	41	40	39	38	37
75	51	50	48	47	46	45	44	42	41	40	39	38	37
76	51	50	49	48	46	45	44	43	42	41	40	39	38
77	52	51	49	48	47	46	45	44	43	41	40	39	38
78	52	51	50	49	48	46	45	44	43	42	41	40	39
79	53	52	50	49	48	47	46	45	44	43	42	41	40
80	53	52	51	50	49	47	46	45	44	43	42	41	40
81	54	53	51	50	49	48	47	46	45	44	43	42	41
82	54	53	52	51	50	48	47	46	45	44	43	42	41
83	55	54	52	51	50	49	48	47	46	45	44	43	42
84	55	54	53	52	50	49	48	47	46	45	44	43	42
85	56	54	53	52	51	50	49	48	47	46	45	44	43
86	56	55	54	52	51	50	49	48	47	46	45	44	43
87	56	55	54	53	52	51	50	49	48	46	46	45	44
88	57	56	54	53	52	51	50	49	48	47	46	45	44
89	57	56	55	54	53	51	50	49	48	47	46	45	44

THE END